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the small systems journal

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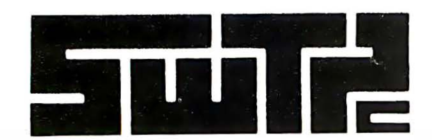
ROBERT TINNEY '81

OPERATING SYSTEMS

YOUR CHOICE-smart either way

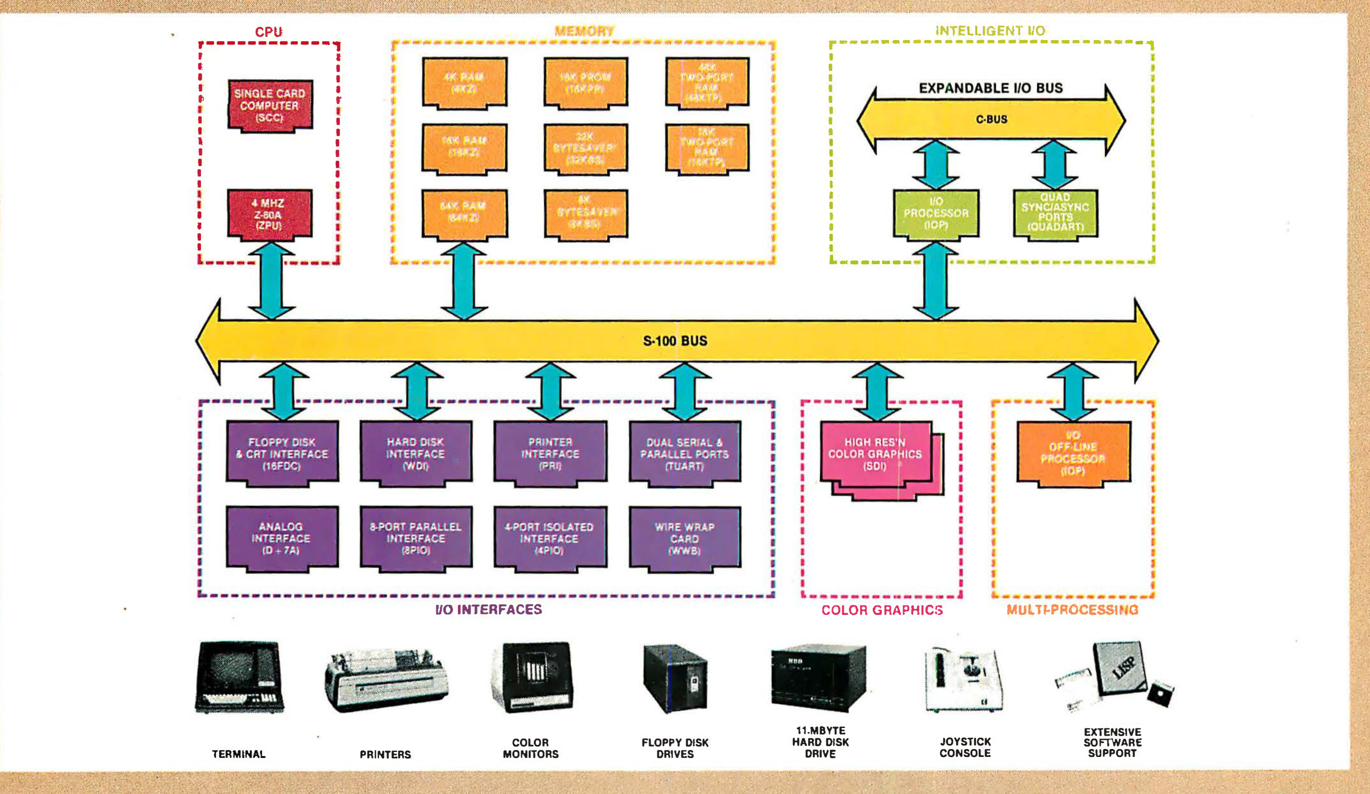
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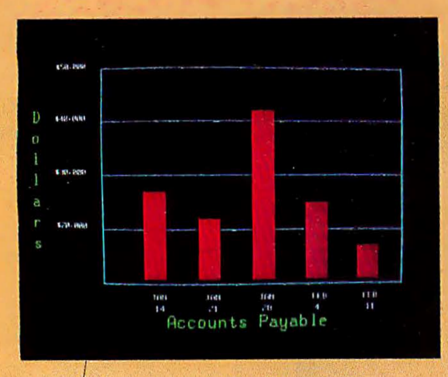
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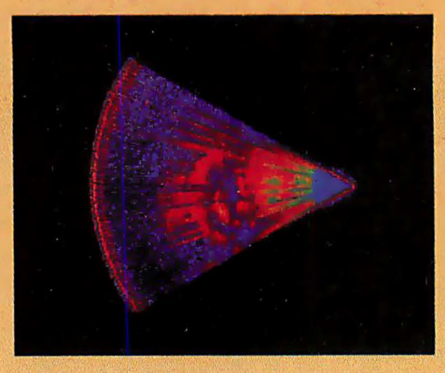
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When we say the SDI results in a high-quality professional display, we mean **you can't get higher resolution than this system offers in an** NTSC-conforming display.

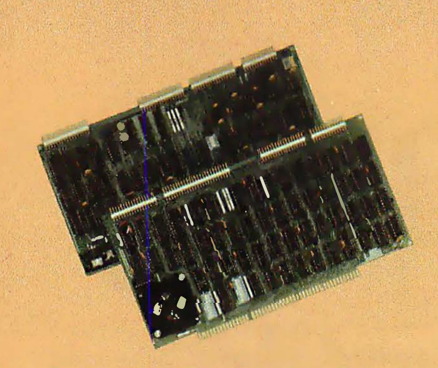
The resolution surpasses that of a color TV picture.

BASIC/FORTRAN programming

Besides its high resolution and low price, the new SDI lets you control with optional Cromemco software packages that use simple BASIC- and FORTRAN-like commands.

Pick any of 16 colors (from a 4096-color palette) with instructions like DEFCLR (c, R, G, B). Or obtain a circle of specified size, location, and color with XCIRC (x, y, r, c).

*U.S. Pat. No. 4121283



Model SDI High-Resolution Color Graphics Interface

HIGH RESOLUTION

The SDI's high resolution gives a professional-quality display that strictly meets NTSC requirements. You get 756 pixels on every visible line of the NTSC standard display of 482 image lines. Vertical line spacing is 1 pixel.

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Model SDI plugs into Z-2H 11-megabyte hard disk computer or any Cromemco computer

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The Model SDI has been used in scientific work, engineering, business, TV, color graphics, and other areas. It's a good example of how Cromemco keeps computers in the field up to date, since it turns any Cromemco computer into an up-to-date color display computer.

The SDI has still more features that you should be informed about. So contact your Cromemco representative now and see all that the SDI will do for you.



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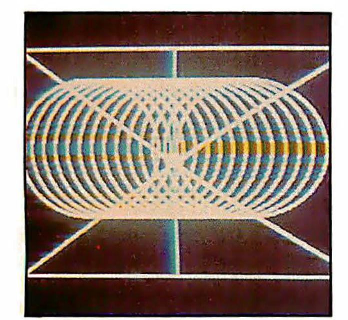
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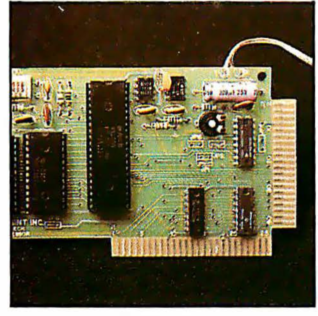
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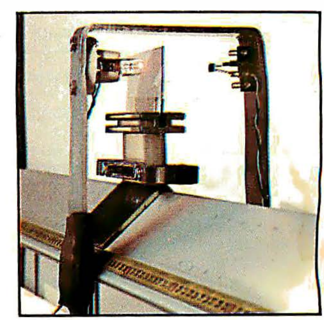
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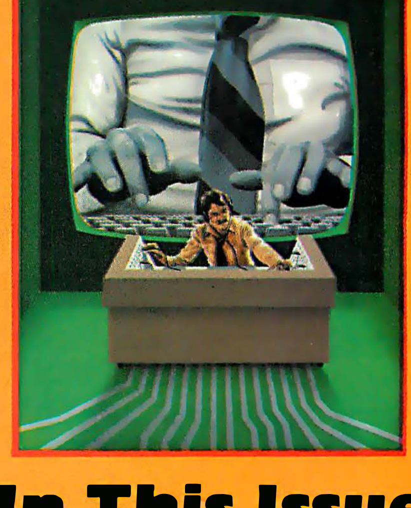


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In This Issue

It's the operating systems that turn a hunk of hardware into a clever machine. As Robert Tinney's cover drawing depicts, they are the brains behind the brawn of today's computing systems.

This month two articles analyze the most popular operating system, "CP/M: A Family of 8- and 16-Bit Operating Systems," by Gary Kildall, and James Larson's "The Ins and Outs of CP/M." If you can get by the title of Chris Morgan's editorial — "The New 16-Bit Operating Systems, or, the Search for Benutzerfreundlichkeit" — you'll discover what form the operating systems of the future may take. And Robert Greenberg presents what may be the next popular operating system in his article, "The UNIX Operating System and the XENIX Standard Operating Environment."

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Editorial

The New 16-Bit Operating Systems, or, The Search for Benützerfreundlichkeit

by Chris Morgan, Editor in Chief

"Benützerfreundlichkeit: (literally 'user friendliness') The philosophy that a system should be constructed with the interests of the user as the chief concern."

—from The Practical Guide to Structured Systems Design *by Meilir Page-Jones, Yourdon Press, New York, 1980, page 338.*

Sam Goldwyn, the "G" of MGM, was famous for his inside-out logic. He once said, "A verbal agreement isn't worth the paper it's written on." This month's topic prompted me to coin a "Goldwynism" of my own: "The best time to talk about the future is before it happens."

In one sense 16-bit microcomputers are definitely here, yet in another they are strangers to us. The personal-computer community still lives in an 8-bit world, straining all 8 bits of every word to perform miracles.

But all that can and must change. Opponents of 16-bit systems cite cost and software conversion problems as the two main justifications for staying with 8 bits. Yet, how can software keep pace with the increased demand for more sophisticated graphics, to name only one area, unless we can address more than 64 K bytes of memory? How will we be able to access the staggering amounts of information in future memory banks without an increase in word size? And then there are the exciting new languages like Smalltalk that demand 16 bits for their operation. Simply put, 16 bits is the only way to go. The 16-bit operating system, therefore, becomes a critical link in the computing chain.

Doing It Right the Second Time

The *operating system* is the "master controller" of the computer: it gets us going when we turn on our computers, keeps track of files, lets programs talk to one another, performs input/output tasks, and so on. Put charitably, most operating systems in the 8-bit world have been afterthoughts or compromises in design. Even CP/M, a de facto standard in our field, has been criticized as being awkward for nontechnical users. But CP/M's ubiquitousness is responsible for the development of a lot of valuable software that would otherwise probably not have been written.

The sin of inefficiency is venial compared to the mortal sin of "user-unfriendliness." I'd buy an operating system any day that takes a long time to run a given program but which makes me more productive by communicating with me in useful ways. Let's face it: most of us don't have to worry about real-time process control and its inherent time constraints. And the cost of a line of code is becoming astronomical.

KEVIN COHAN *1956-1981*
Kevin Cohan, BYTE technical editor, died April 22nd when the car he was driving left the road, striking a tree. He was 24 years old. Kevin joined the BYTE staff in November, 1980, after attending Dartmouth College, and was a valuable and well-liked member of our "family." He will be missed.

Percom Mini-Disk Drive Systems for TRS-80* Computers...

Now! Add-On *and* Add-In Mini-Disk Storage for your Model III.



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Patterned after our fast-selling TFD Model I drives. And subjected to the same reliability controls. These new TFD mini-disk systems for the Model III provide more features than Tandy drives, yet cost far less.

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  Moreover, the initial drive may be **either** an internal add-in drive or an external add-on drive. And whichever configuration you get, the initial drive kit comes complete with our advanced 4-drive controller, interconnecting cables, power supplies, installation hardware, a DOS and of course the drive mechanism itself.
- **First Drive Includes DOS:** OS-80™, Percom's fast extendable BASIC-language disk operating system, is included on diskette when you purchase an initial drive kit. Originally called MicroDOS, OS-80 was favorably reviewed in the June 1980 issue of Creative Computing magazine.
- **Works with Model III TRSDOS:** Besides being fully hardware compatible, Percom's Model III 40-track drive systems may be operated with Tandy's Model III TRSDOS — without any modifications whatsoever. And, TRSDOS may be easily upgraded with simple software patches for operating 80-track drives.

Percom TFD add-on drives start at only $399. Model III Drive kits start at only $749.95.

Quality Percom products are available at authorized dealers. Call *toll free 1-800-527-1592* for the address of your nearest dealer or to order direct from Percom.

Still #1 for Model I

As if greater storage capacities, exceptional quality control measures and lower prices aren't reasons enough to make Percom your first choice for Model I add-on drives, **all** Percom Model I drives are also rated for double-density operation.

Add our innovative DOUBLER™ adapter to your Model I Expansion Interface, and with Percom drive systems you can enjoy the same double-density storage capability as Model III owners.

The DOUBLER includes a TRSDOS*-like double-density disk operating system called DBLDOS™

We also offer a double-density Model I version of OS-80 as well as DOUBLEZAP programs for modifying NEWDOS/80 and VTOS 4.0† for DOUBLER compatibility.

Of course you don't have to upgrade your computer for double-density operation to use Percom mini-disk drive systems. In single-density operation, our TRS-80* Model I compatible 40-track drives store 102 Kbytes of formatted data on one side of a diskette, and our 80-track drives store 205 Kbytes. By comparison, Tandy's standard drive for the Model I stores just 86 Kbytes.

And like our Model III drives, Model I add-on drives are optionally available with "flippy" storage capability.

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Model III: 16-Kbyte system (min) and Model III BASIC. The second internal drive may be installed after the first internal drive kit is installed, and external drives #2, #3 and #4 may be added if either an internal or external first-drive kit has been installed. External drives #3 and #4 require an optional interconnecting cable.
Model I: 16-Kbyte system (min), Level II BASIC, Expansion Interface, disk operating system and an interconnecting cable. For double-density storage, a Percom DOUBLER must be installed in the Expansion Interface and DBLDOS (comes with the DOUBLER) or other double-density DOS must be used. For single-density operation, a Percom SEPARATOR™ adapter, installed in the Expansion Interface, will virtually eliminate "CRC ERROR — TRACK LOCKED OUT" read errors. Prices and specifications subject to change without notice.



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No matter which option you choose, you get the benefit of working with completely integrated products ... fully assembled and tested ... under one warranty and one price structure ... leaving you free to concentrate on value-added application development and sales.

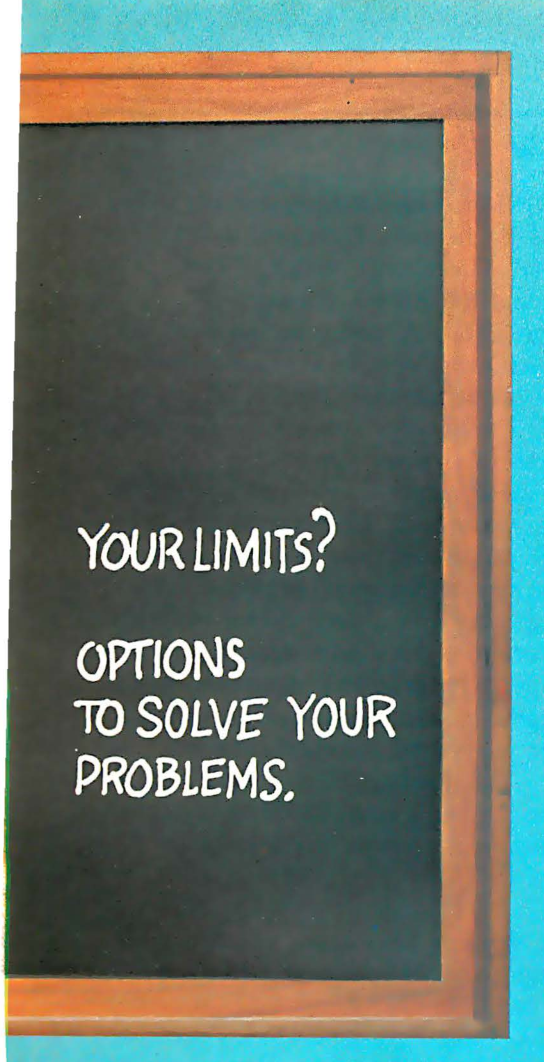
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Select from three packaging options: Rack-mount, table-top or front panel models. All three feature our 20 slot S-100 motherboard with 25 amp power supply and are delivered fully assembled and tested with our Series II™ board sets. Any board configuration you choose works with any DPS-1 version, allowing you to vary your package offering, or develop on one version and market another.

- Front Panel model — a powerful development and diagnostic tool for Z-80† systems, which can be used for prototyping, servicing, debugging, and software or hardware development. Use its features to set breakpoints, trigger scopes, single step, slow step and more.
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- Rack Mount version — features a heavy gauge frame designed to fit into standard 19" racks. CVT power supply for brown out immunity is standard.

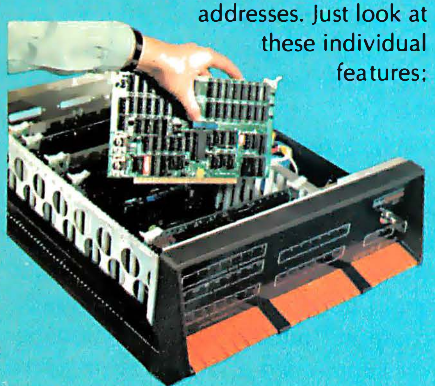
*In Calculus, a fundamental statement in the definition of limit; interpreted here to imply: "For your integration problem, Intersystems has a solution."

† Registered trademark of Zilog, Inc.



Board level options . . .

Intersystems mainframe packages, equipped with Series II boards, are operational in both 8 and 16 bit settings and support extended addressing in both I/O and memory space, recognizing 16 bit I/O addresses and 24 bit memory addresses. Just look at these individual features:



- MPU-80—uses a Z-80, 8 vectored interrupt lines and two 4K windows to address up to 1 Megabyte of RAM without bank select.
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- 6 SI/O — six individually software-controllable serial I/O ports with optional interrupts. Each can run RS 232 at up to 19,200 BAUD, as can our VI/O board.
- VI/O—has two serial ports; two 8-bit parallel output and two 8-bit parallel input ports plus 8 individually controllable command lines and 16 levels of vectored interrupts.
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We use it for our own hardware and software development. It includes either table-top mainframe, two 8" floppy disks, 128K RAM, CP/M#, and Intersystems Pascal/Z™ compiler and Cache BIOS™.

THIS SYSTEM IS FAST! Why? Because our ultra-fast Cache BIOS automatically buffers whole tracks, eliminating most disk accesses. This delivers up to three times the throughput of any other floppy-based system we know and is equal to many small hard disk systems.

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Editorial

Now we have a chance to start with a clean slate. Software manufacturers are filling their 16-bit tabula rasas with offsprings of UNIX, an operating system developed at Bell Labs in 1969 by Kenneth Thompson and Dennis Ritchie. (See Robert Greenberg's article, "The UNIX Operating System and the XENIX Standard Operating Environment," page 248.) A software engineer was quoted in a recent issue of *Electronics* magazine (March 24, 1981, page 119) as saying that UNIX is "like sitting behind the wheel of a well-tuned sports car—when you press the gas, it goes, and when you hit the brakes, it stops. It's the ultimate in responsiveness, and yet all the while you are riding in comfort." UNIX deserves such accolades. Its hierarchical file structure lends much needed order to the chaotic approaches found in many personal computer operating systems; it is designed for truly efficient multiuser operation; the elegant idea of the *pipe* allows data to flow from program to program efficiently; and the *shell* program acts as a user-friendly interface to the rest of the operating system. An excellent example of UNIX's versatility, described in Greenberg's article, shows how the user can add a simple spelling correction program to a system, with just one line of code.

New Programs

Several software vendors have taken out licenses to adapt UNIX to 16-bit personal computer systems. These include Microsoft, Whitesmiths, Zilog, and Onyx, the developers of XENIX, Idris, Zeus, and Onix, respectively. Among non-UNIX-related 16-bit operating systems, OASIS, developed by Phase One Systems Inc, has received high marks from many professional programmers. And judging from its past track record with CP/M, Digital Research's new CP/M-86 should also become a major factor in the market. (See "CP/M: A Family of 8- and 16-Bit Operating Systems," by Gary Kildall, page 216.)

Despite the recent relaxation of UNIX licensing fee conditions by Western Electric, the UNIX offspring will not be cheap. Operating system software could sell for more than $2000. However, Lifeboat Associates' version of XENIX will probably retail for less than $1000 by the end of the year.

The 8-bit computer is far from dead. There is too much good 8-bit software around for this to happen. And, for many applications, it's hard to beat the price-performance ratio of the 8-bit machine—at least by today's prices. Sixteen-bit and 8-bit machines will coexist for many years to come. I don't believe in the "mutually exclusive" school of computer punditry. Just as no high-level language has ever supplanted another (can readers give me an example of this?), 8-, 16-, 32-, (etc) bit microcomputers will coexist in the future.

In our field, the future becomes the present overnight. You don't need a crystal ball to state emphatically that we have not seen the end of the 8-bit versus 16-bit debate. But the new operating systems do add a welcomed layer of professionalism to personal computing.■

Apple* I/O Interfaces. SSM Spells Success Three Ways.

SSM helps you get the most from your Apple II* computer. Choose from three general purpose interface boards. With flexibility and prices that translate to big savings. Now, and when you upgrade.

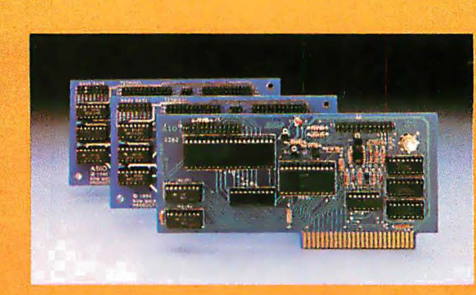
Serial (ASIO™). Our ASIO gives you a full-duplex RS-232 interface. Plus jumper-selectable rates from 110 to 9600 baud. You also get software control, three handshaking lines and two output plugs—so you can connect your Apple to a modem or to a terminal/printer without modifying the cable.

Parallel (APIO™). For parallel interfaces, our APIO offers two 8-bit bidirectional ports. We also include additional interrupt and handshaking lines, plus software control of the interface configuration and data direction. Cables for Centronics and other printers are optional.

Or Both (AIO™). Choose our tried and proven AIO when you need a sometimes-serial or a sometimes-parallel operation. This single-board solution packs a lot of performance for the price. Thousands are now being used. It even lets you operate both ways—simultaneously—under Pascal, or with special drivers.

All three boards feature powerful firmware so you don't have to write software to use them. The ASIO and AIO include cables.

Whether you're an OEM or end-user, we can supply virtually any quantity you need. Quickly. Even in kit form. For the latest word on these, see your local computer dealer. Or call us today. You may also want to look into our cost-effective A488™ board which converts your Apple II into an IEEE-488 controller.





SSM Microcomputer Products, Inc.

SSM Microcomputer Products, Inc., 2190 Paragon Drive, San Jose, CA 95131. (408) 946-7400. (TWX 910-338-2077. Telex 171171.)

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OSI Still In Personal-Computer Business

As a result of "Ohio Scientific Sold" ("BYTELINES," March 1981 BYTE, page 246), we have had several telephone calls from dealers who were disturbed by BYTE's report that "In all likelihood OSI will move away from personal computing and into the small-business market." This statement is a false and damaging "projecture."

When Ohio Scientific was founded in 1975, our first products were designed for, and directed to, the personal-computer market. In 1977, when other small-computer manufacturers were entering the "fun and games" computer market, OSI introduced the Challenger C3B Business Systems, featuring a three-processor system with 74-megabyte Winchester hard-disk storage.

As a pioneer in small business-computer systems, we feel we moved into the small-business market some time ago. Our first business-system advertisements appeared in BYTE in 1978!

As for our personal-computer systems, now and for the future—in May 1980, we announced an enhanced version of our Challenger C1P and introduced our Challenger C1P Series 2. In total units and dollar volume, we are counting heavily on our personal-computer line to carry a full share of Ohio Scientific's continued success.

W Paul Warren
Coordinator, Marketing Communications
Ohio Scientific
1333 S Chillicothe Rd
Aurora OH 44202

We are sorry for any misinterpretations of Sol Libes's speculation on the future of OSI's marketing strategy. We were not implying that OSI will drop its personal-computer line, but that we feel that there may be a shift in its marketing emphasis. . . . **MH**

BYTELINES Makes Waves

I have always enjoyed reading Sol Libes's "BYTELINES," and consider him to be a good source of information on the personal-computer industry, except for one annoying trait. Because Mr Libes is professionally associated with products that use the S-100 bus, his information is strongly biased toward Intel and S-100 products. For example, I recently counted six issues in a row where he discussed UNIX-like software to be introduced for Intel and S-100 users. At no time did he mention that the Motorola/S-50 users have had UNIX-like systems available for some time. Certainly he has seen the advertisments in BYTE for UNIFLEX for the 6809 by TSC (Technical Systems Consultants). If Mr Libes hasn't heard of the UNIX-like OS-9 by Microware, it is only because he looks at the world through S-100 blinders. Perhaps "BYTELINES" should be expanded to include associate editors who would supply information on other computer buses and the popular "no-bus" systems.

Leo Taylor
18 Ridge Ct W
West Haven CT 06516

Sol Libes Replies:

I am pleased that Leo Taylor enjoys reading my column and considers it "a good source of information." There is no doubt that I have a bias toward S-100-based systems—I guess it's my upbringing. I try to control it and present a balanced picture of the personal-computing field. I feel that I am successful 99% of the time, and that no one can be 100% unbiased.

When I wrote the UNIX items for "BYTELINES" during the spring and summer of 1980, TSC had not yet announced UNIFLEX, so I was not aware that it was coming. Additionally, nowhere in TSC's advertisements is it specifically stated that UNIFLEX is "UNIX-like," although the description sure sounds like it is.

The OS-9 operating system fell into the same category as UNIFLEX. Despite the fact that its advertisements refer to OS-9 as UNIX-like, a product review, in the December 1980 issue of 68' Micro Journal, *stated that "the similarity [to UNIX] is mostly superficial."*

Treasure on Disk

I enjoyed the reviews and comments on the Adventure-like games in the December 1980 BYTE, especially Jerry Pournelle's "User's Column." (See "BASIC, Computer Languages, and Computer Adventures," page 222.) I would, however, like to point out for the benefit of BYTE's readers that the original version of Adventure ("The Colossal Cave") has been available from the Heath Users' Group for over two years, for a mere $10.

This version comes on a 5-inch disk that runs on the Heath H-8 (with disk drive) or the H-89 computers. A minimum of 32 K bytes of memory is required, and the game plays very fast. Unlike other issues, Heath's version (written by Gordon Letwin before he left to join Microsoft) can be easily copied for backup and safe keeping—a distinct plus.

I'd also like to point out that while there are several maps and guides available to the Colossal Cave, none help that much. They may assist in reducing the search for treasures, but they won't help in avoiding some of the more subtle pitfalls, and certainly won't help in the Final Adventure.

D C Shoemaker
2000 A Foxridge
Blacksburg VA 24060

More GOTOs Changing

In David Carew's article "Change Your GOTOS into FOR...NEXT Loops" (January 1981 BYTE, page 334), a better approach to the problem would have been (if step 0 not allowed):

```
510 FOR I = 1 TO 2
520 READ X
530 I = 1
535 IF X = K THEN I = 2
540 NEXT I
```

However, the best way, for systems that allow it, is:

```
510 FOR I = 0 TO -1 STEP -1
520 READ X
530 I = X = K
540 NEXT I
```

For the TRS-80 (and, I think, all Microsoft BASICs), line 530 treats the second equals sign as a logical operation, giving a −1 (true condition) if equal, and a 0 (false condition) if not equal. Some BASICs have a different convention for true and false (some represent true as 1 and false as 0) so the statement would be FOR I=0 TO 1. Another advantage of this form is that it can be embedded in the middle of a long line as follows:

```
500 ..... : FOR I = 0 TO -1 STEP -1
          : READ X : I = X = K : NEXT : ....
```

Both of these examples are faster than the published counterparts—always setting I to 1 is faster than the test (even if false), because there are fewer characters to interpret, and the same goes for the other example. Also, both of these examples use less memory for the program.

Carey Tyler Schug
POB 585
Chicago IL 60690

CMOS Is Boss

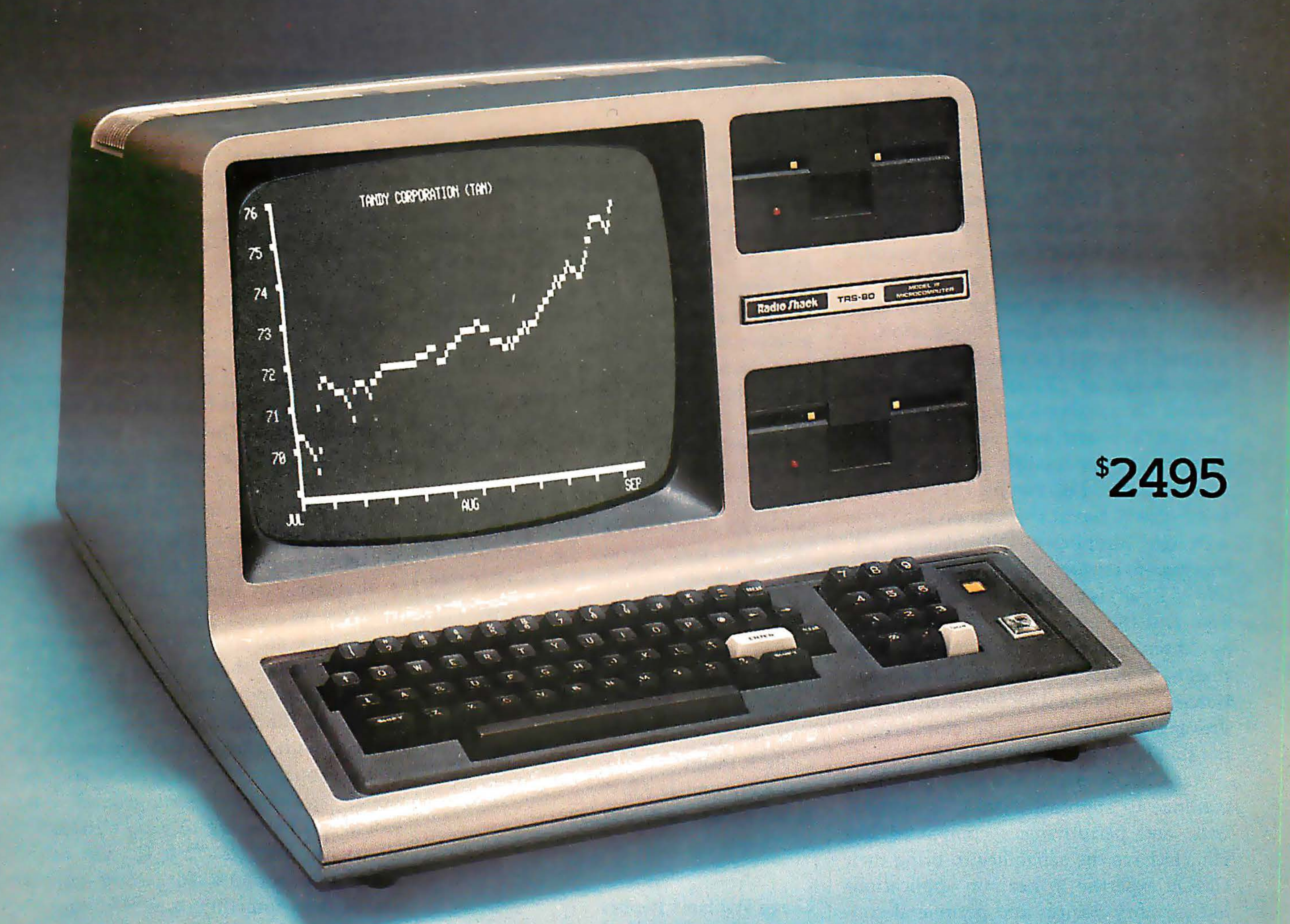
A few important points need to be made in connection with Larry Malakoff's article "Memory: Making an Intelligent Decision." (See the February 1981 BYTE, page 142.) Mr Malakoff generalizes that dynamic memories are superior in the areas of packing density, power consumption, and cost. Unfortunately, he has overlooked one of the most exciting memory techniques currently available: CMOS (complementary metal-oxide semiconductor) *static* memories.

While we at Hitachi are active in the dynamic memory business (especially the 4816-type 16 K by 1-bit and the 4864-type 64 K by 1-bit devices), we recognize that, for many reasons, static memory is often desirable. This approach is typified by our CMOS 6116-type fully static 2 K by 8-bit memory.

Responding to each of Mr Malakoff's points:

- Density: Using the 6116, a 64 K-byte static memory board is not only feasible, but Godbout Electronics will soon release an S-100-compatible board, called RAM 17. The increased size of the 6116's package (24 pins versus 16 pins for the 4116-type dynamic device) is easily offset by the total lack of "tricky" refresh logic required by dynamic memory.
- Power Consumption: The 6116's power requirements (operating *and* standby) are equal to or less than most 16 K-bit dynamic devices. The power supply to Godbout's 64 K-byte static board is con-

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servatively overregulated using one 7805 5 V, 1 A voltage regulator.

- Price: Expect the price of Godbout's RAM 17 to be competitive ($1400) with the $895 to $1195 figures quoted by Mr Malakoff.

A few other points:

- Compatibility: The 6116 is easy to interface and is fully compatible with all processors, DMA (direct memory access) controllers, front panels, etc. Boards like those mentioned in the article may not work with faster processors (eg: 6809, 8088) now available for the S-100 bus.
- Versatility: The 6116 is pin-compatible with the 2716 EPROM (erasable programmable read-only memory) and Hitachi's new 48016 EEPROM (electrically erasable PROM), and so the user can configure a board to contain the best combination of memory types for a given application.
- Speed: The 6116 is available for speeds rated as fast as 120 ns (more than fast enough for microprocessor applications). Godbout's board will work with Z80 microprocessors running at 6 MHz with no wait states. I do not believe that there is a dynamic board that can do the same.
- Design Simplicity: No "black art" transparent refresh or special circuitry (eg: DMA, Reset) is needed; consequently, the time and the cost of the design process have been reduced. (For systems with more than 64 K bytes of memory, the best solution is to adopt the IEEE 696 Extended Addressing Standard, not the cumbersome nonstandard bank-select scheme.)

As CMOS manufacturing processes continue to approach NMOS in density, cost, and performance, companies like Hitachi have the capability to bring their CMOS expertise to bear on applications like memory devices and peripheral controllers. As devices become more complex, and applications more demanding, CMOS technology will be *required* to overcome thermal dissipation problems.

Thomas Cantrell
Microprocessor Product Marketing
Hitachi America Inc
1800 Bering Dr
San Jose CA 95112

Hand-Held Computer Algorithm Improvement

I read with interest Gregg Williams's description of the Panasonic and Quasar hand-held computers, especially the data-compression techniques. (See "The Panasonic and Quasar Hand-Held Computers," January 1981 BYTE, page 34.) Reading the text box that describes the mapping algorithm, however, I noticed a possible improvement.

In figure 3, page 41, a permutation of four elements encoded with 6 bits (001010, by rows) is demonstrated. However, according to the text, the first box will always be unswitched. Since it is constant, the first box (or first bit) need not be stored explicitly. This leaves 5 bits instead of 6 to encode the permutation (01010 for the example). The recursive nature of the algorithm should compound the savings significantly for larger permutations. In table 1, I have reproduced Mr Williams's table 2 with an additional column.

Table Rank (N)	Number of Elements in Table (2^N)	Williams's Algorithm $F(N) = 2^N + 2F(N-1)$	Modified Algorithm $F'(N) = 2^N + 2F'(N-1) - 1$	Ordinary Lookup $N2^N$
1	2	1	1	2
2	4	6	4 + 2(1) − 1 = 5	8
3	8	20	8 + 2(5) − 1 = 17	24
4	16	56	16 + 2(17) − 1 = 49	64
5	32	144	32 + 2(49) − 1 = 129	160
6	64	352	64 + 2(129) − 1 = 321	384

Table 1

Craig R Ewert
400 Raymondale #16
South Pasadena CA 91030

Gregg Williams Replies:

Your analysis of the requirements of the algorithm is completely correct, although this does not necessarily mean that even more space can be saved within the HHC (hand-held computer). I compiled the table of results you referred to based on a description of the algorithm, and I did not realize that the box in the upper-left corner did not need to be encoded. Although I was unable to contact the person who had written the code implementing the algorithm, your interpretation of the algorithm does, in fact, allow permutations to be stored with less memory. My thanks to you (and to Paul E Black, of Oquirrh City, Utah, who wrote a similar letter) for pointing this out.

Thermodynamic Flaws

Richard Hetherington's excellent "Programming Quickie" in the February 1981 BYTE contains one flaw that can cause the user of his routine to arrive at some misleading results. (See "Energy-Saving Cost/Benefit Analysis," page 266.)

Table 2 gave the heat value of various fuels, and as far as I can see, it's correct. Unfortunately, the heat values are theoretical maxima, and to compute cost savings you need to make allowances for inefficiencies in extracting that heat. In practice, efficiencies range from (essentially) 100% for electricity to 20% or less for a fireplace. (A small fire in a large fireplace on a cold night can actually run at negative efficiency—losing more heat up the chimney than it contributes to the house.) Efficiencies tend to vary with the quality of the heating hardware, and (I suspect) with whether they are measured in the laboratory or in a more conventional environment. In general, you would not be wrong to expect 100% for electricity; 60% to 70% for gas or oil heat; 40% to 50% for wood or coal stoves; and something pretty dismal for an unaugmented fireplace.

The conventional means of accounting for this are either to reevaluate the fuel's heat value by the efficiency, or to alter the equation C=Z*Q/H to read C=Z*Q*E/(100*H), where E is the efficiency in percent. In this case, I would modify the routine to use the latter method, because it lets you evaluate the effect of switching to a more efficient heat source.

Anyone seriously planning to tackle his or her home-heating problem should construct a paper-and-pencil thermodynamic model of his or her house. This is nowhere near as difficult as it sounds. Any public library has some books (mostly those dealing with solar heating) that can help.

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Circle 170 on inquiry card.

Mr Hetherington's routine is only as good as the data you put into it, and if you don't know how much heat you are putting into your house, and where it is going out, you may not recognize bad data when you use it.

Donald Kenney
291 S Main St
Andover MA 01810

Computers Can Help People

I read Mark Dahmke's editorial and would like to share with BYTE readers an interest of mine. (See "Computer Speech: An Update," February 1981 BYTE, page 6.)

I'm an academic adviser at Michigan State University and work with students in the Lower Division. Among our many academic services, we try to assist students in selecting majors that will help them attain their individual goals in life. I have very realistic concern and at the same time very optimistic hope for one student in particular.

Kelly Watson is a quadriplegic and has a combination of athetoid and spastic cerebral palsy. She is a delightful young lady—bright, pretty, and her sparkling sense of humor helps her overcome frustration. Kelly, although just 20, became a sophomore at the end of this winter term. She has gotten this far in her academic career out of sheer determination, and I'm sure someday she will be the newspaper editor she plans to become.

Kelly uses a joystick-operated electric wheelchair and types with a headstick on an IBM electric typewriter. MSU's Artificial Language Laboratory hopes to be able to provide her with a word-processing system. With financial assistance from concerned communities, technologists such as Mark Dahmke and John Eulenberg will soon be able to make accessible to persons such as Bill Rush and Kelly Watson those opportunities we all enjoy. I foresee a great advancement in human concern.

Jane E Linnell
Michigan State University
Undergraduate University Division
Student Academic Affairs Office
East Lansing MI 48824

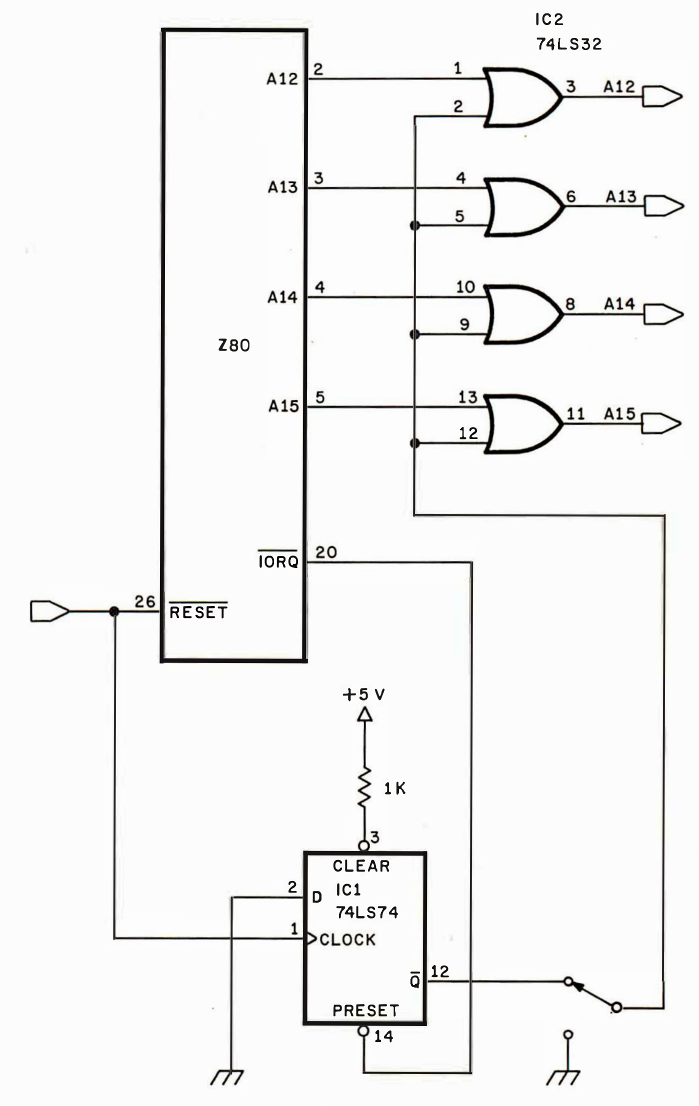


Figure 1

Simpler Starting Solution

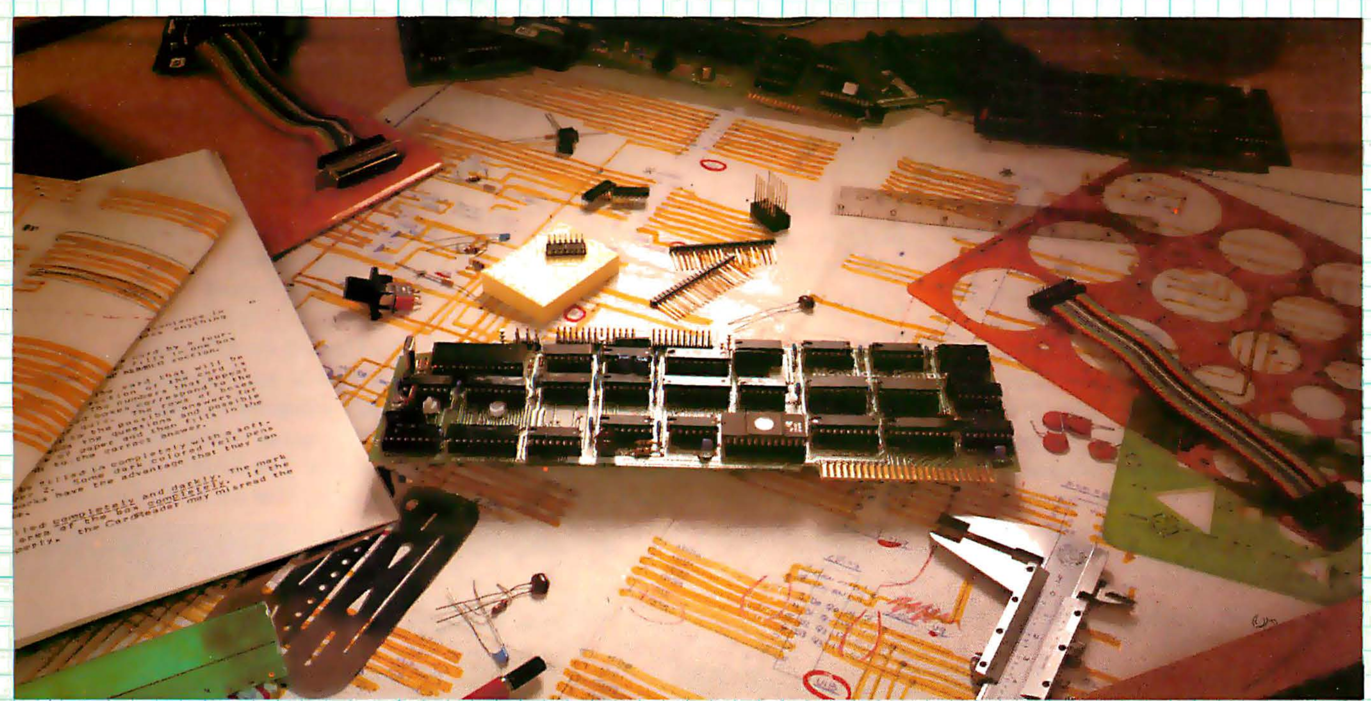
Although Randy Soderstrom's approach to the problem of forcing the Z80 starting address was interesting, it is not the simplest solution. (See "Forcing the Z80 Starting Address," February 1981 BYTE, page 288.) His suggestion requires four integrated circuits, and an initial time delay is introduced. The circuit in figure 1 uses only two devices.

Upon reset of the system, the D flip-flop (IC1) is clocked, causing $\overline{Q}$ to go high. Although the processor's address bus and program counter contain all 0s, the memory addressed is hexadecimal F000. The 74LS32 quad OR gate (IC2) accomplishes this with one input per gate high. The system monitor can be stored at hexadecimal address F000 and can now handle its high-priority housekeeping without worrying about the address. A JP (jump immediate) to the next instruction will set the program counter correctly. The first OUT or IN instruction will activate the IORQ (input/output request), and then preset the D flip-flop, allowing signals on the address bus to pass freely through the 74LS32, and restoring the system to normal operation. As in Randy's circuit, there is no interference with memory refresh.

This technique is used on MOSTEK's STD Bus-based CPU-1 card. We feel this is the best and most economical approach to take.

Mitchell A Russo
MOSTEK
29 Cummings Pk, Suite 426
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BASIC Problems

Samuel Bates's "Rotation Algorithm" was fascinating but frustrating for two reasons. (See the January 1981 BYTE, page 328.) First, there are many terms used from Hewlett-Packard's HP 3000 BASIC that are not common to other versions of BASIC. I can figure out what MAT R=ZER does (it puts 0 in every element of the array R) and duplicate it with a subroutine, and I can determine from context that # means <> (not equal). However, I'm stymied by FILES*, ASSIGN, ENTER, and READ#1,1. Please, BYTE, return to the old policy of inserting a box with explanations of uncommon terms! A flowchart would have been useful, too.

"Whose BASIC Does What?" by Teri Li was also welcome. (See the January 1981 BYTE, page 318.) I hope its idea will be extended both to cover more computers and to be more complete in terms. I hope that BYTE will eventually publish it as a separate reference booklet. There were, however, some errors in the article. For the Commodore PET, the major errors of significance are:

HOME and CLS should be checked.
COLOR=n, FRE(x$), SPC(expr), and RANDOMIZE should not be checked.
CALL address should have SYS entered.
TI(expr) should be TI or TI= expr.
TI$, a different real-time clock function, should be listed.

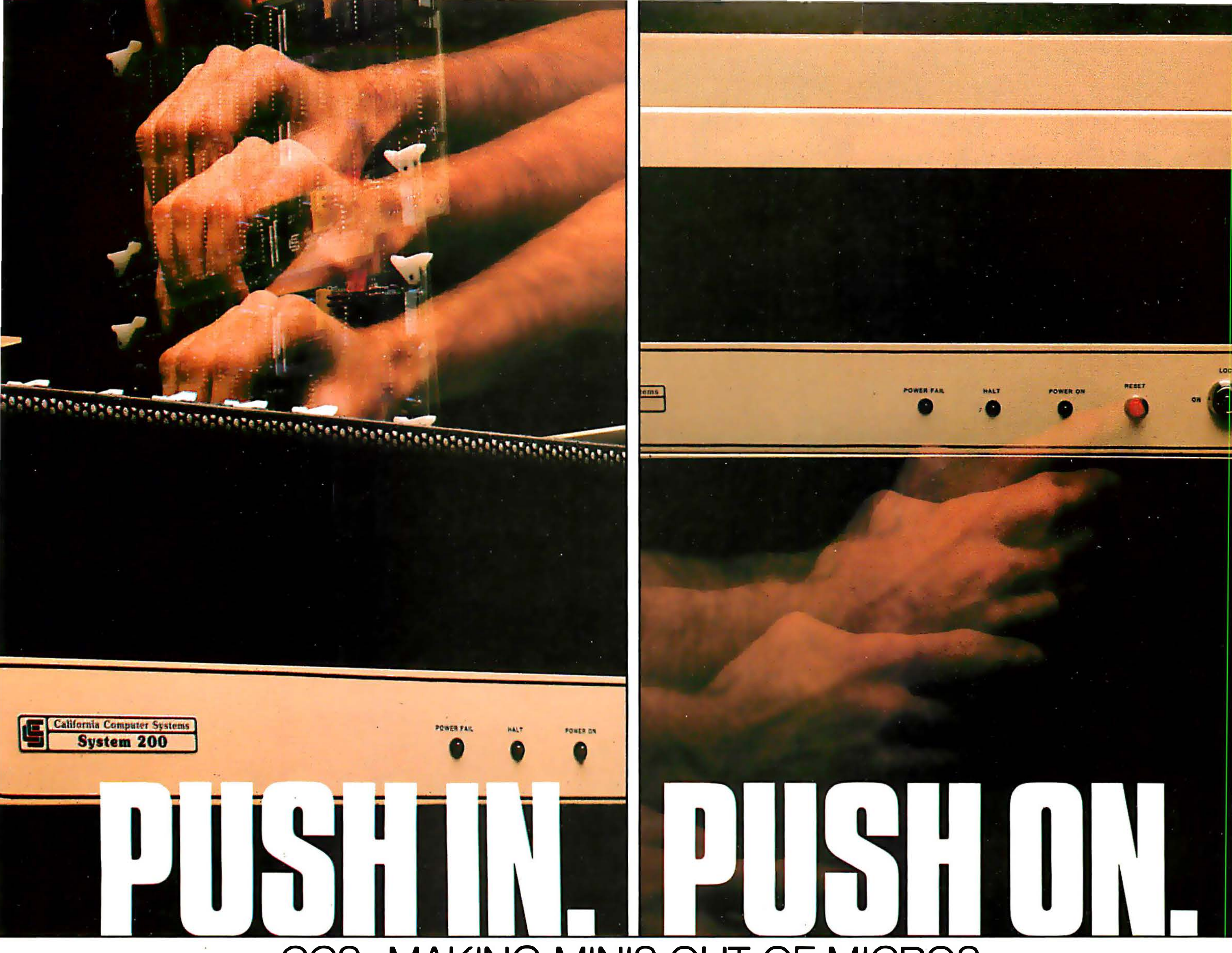
I don't need to say that BYTE is the best (I read six other journals regularly as well), so I'll just say "thanks and keep it up."

Frank Chambers
Rock House
Ballyoroy, Westport
County Mayo, Ireland

The Hewlett-Packard 3000 is correctly classified as a minicomputer, so only a small percentage of our readers will have access to a system similar to the one used by Mr Bates. The BASIC statements that may be unfamiliar are defined in table 2. ■

10 FILES *	tells the interpreter that file names will be provided in a later ASSIGN statement
120 ASSIGN A$,1,S	assigns A$ as file number 1, a sequential file
160 ENTER 255,A9,A$	allows 255 seconds for the values A9 and A$ to be input
1130 READ #1,1	sets the pointer for file number 1 to the first record
1140 IF END #1 THEN 1190	transfers control to statement 1190 if end-of-file number 1 is encountered
1150 READ #1,B$	reads the next value from file number into the variable B$

Table 2



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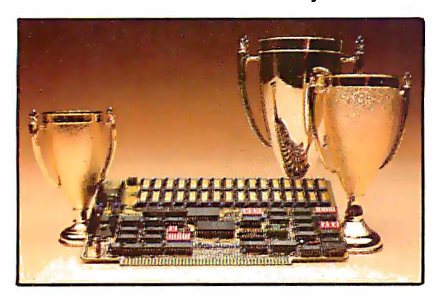
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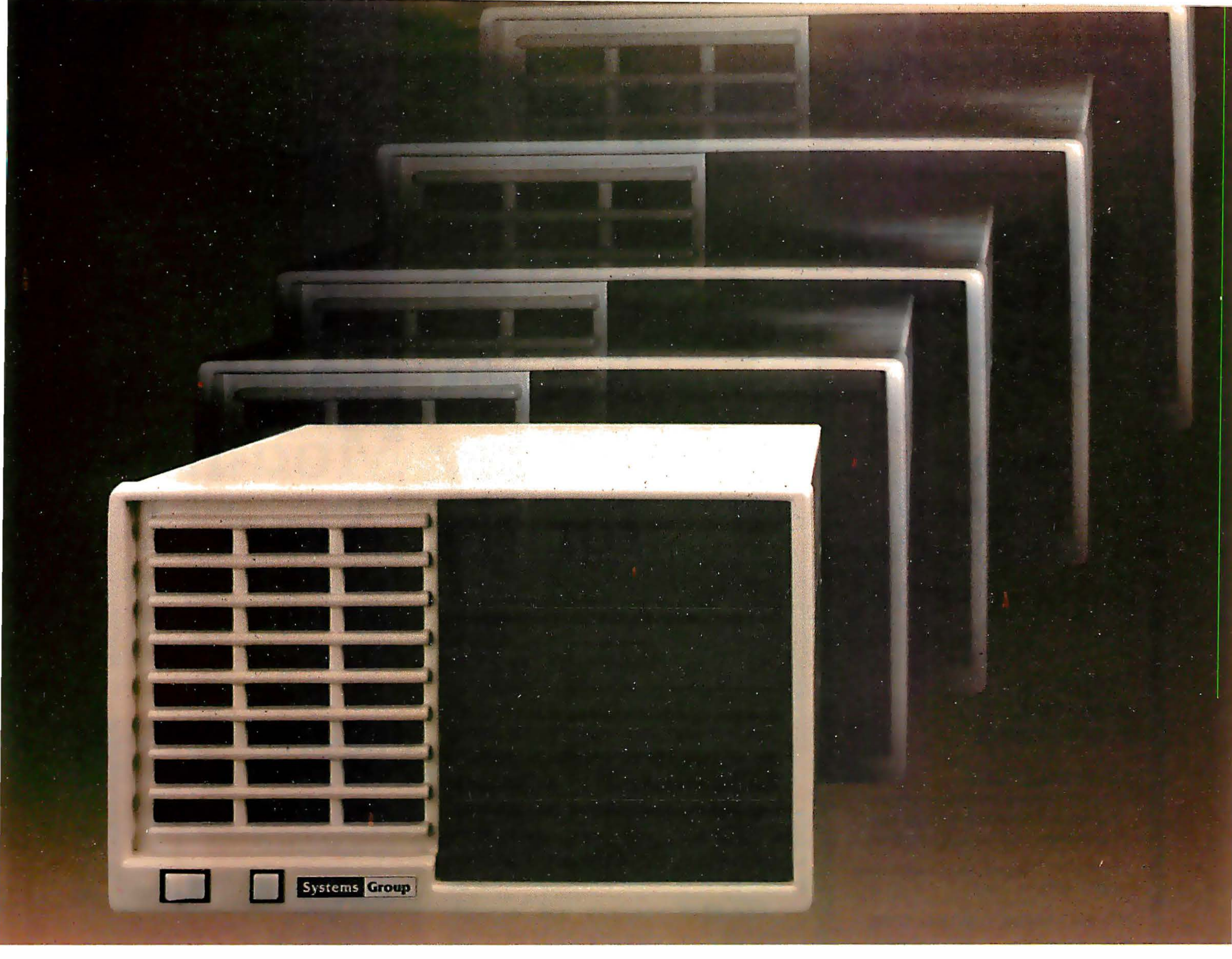


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Hardware Review

RAMCRAM Memory Module for the Atari

Mark Pelczarski
1206 Kings Circle
West Chicago IL 60185

Axlon Inc has released an alternative for add-on memory for the Atari computers that might save some money for Atari 800 owners. RAMCRAM will also offer more memory for the Atari 400 than you may have thought possible.

For $320 you can buy a single module that contains 32 K bytes of programmable memory. The unit plugs into the middle memory slot of an Atari 800, and with the 16 K-byte module provided with your system, gives a full 48 K bytes of memory (it will not work with only an 8 K-byte module ahead of it).



Photo 1: *The Axlon RAMCRAM memory cartridge for the Atari 400 or 800.*

In an Atari 400, the module can replace the built-in 8 K bytes of memory to give a 32 K-byte system. The Atari 400 would then be able to use any software for Atari 800 32 K-byte systems, plus it would contain enough memory to handle a DOS (disk operating system) and, therefore, a floppy-disk drive. With RAMCRAM, Personal Software's 17 K-byte VisiCalc will run on the Atari 400.

In an Atari 800, the top 8 K bytes of memory-address space are preempted if you have a cartridge in the left slot, such as BASIC, the Editor/Assembler, or Star Raiders. With a left cartridge installed you can use only 40 K bytes. Without a cartridge, but with RAMCRAM installed, you have 48 K bytes of memory which can be used for copying disks faster on a one-drive system. (DOS does not require a cartridge, and more programmable memory means swapping disks fewer times while copying.) You also have 48 K bytes for machine-language programs that do not need cartridges, such as VisiCalc, and languages could be loaded from disk without using cartridges.

Axlon also provides its dealers with a memory-diagnostic program that will analyze the memory of an Atari

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800, checking that the full 48 K bytes are functional. It performs three tests: the first tries to zero every bit in memory, the second checks for memory uniqueness by turning on bits and testing whether other bits were affected, and the third rolls a 1 bit through each location, checking that every bit can be turned on. The diagnostic program is available to customers for $15.

If you own an Atari computer and you're the type of person that thinks ahead more than a year, it seems as though RAMCRAM is the way to go for memory expansion. If you own an Atari 400, it gives you memory that you couldn't get otherwise. If you own an Atari 800, it gives you all the memory it can now hold *and* leaves one expansion slot open for future use. Given Axlon's plans for additional Atari-compatible products, that slot may be valuable. ■

At a Glance

Name
RAMCRAM

Use
Increases programmable-memory capacity of Atari computers

Manufacturer
Axlon Inc
170 Wolfe Rd
Sunnyvale CA 94086
(408) 730-0216

Dimensions
7.5 by 15.5 by 1.5 cm (3 by 6 by 5/8 inches)

Price
$320

Features
Expands Atari 800 to 48 K bytes, replaces existing memory in Atari 400 to give a total of 32 K bytes

Hardware needed
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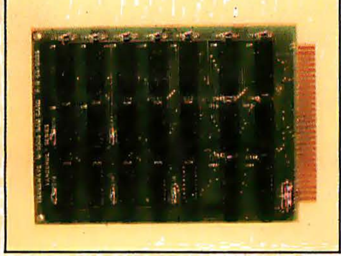
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K-8073

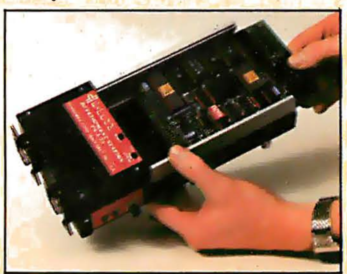
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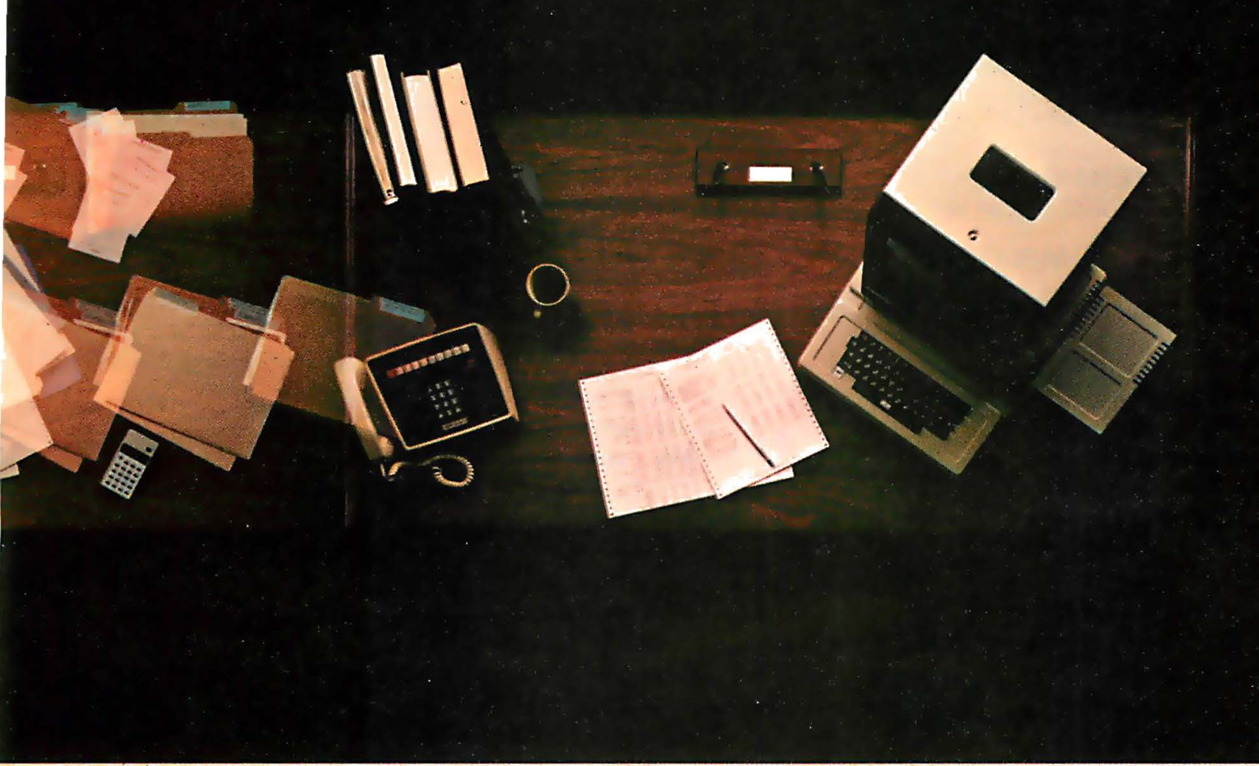
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Technical Forum

LISP vs FORTRAN
A Fantasy

Laurie Rocheleau
c/o David Clay
Florida Institute of Technology
Melbourne FL 32901

Editor's Note: *David Clay, an instructor of computer science at the Florida Institute of Technology, sent us an interesting short story written by one of his students. In his cover letter, he wrote:*

"I assigned a short term paper recently on the comparison of two programming languages, LISP and FORTRAN. Most papers were written in an expected style, outline of topics, and format—until I came to Laurie Rocheleau's. I was surprised, entertained, and impressed. After reading it, I felt that others might find it a novel approach to a somewhat mundane academic chore—writing term papers."

We, too, were surprised, entertained, and impressed, so we decided to publish this short story/term paper. We also want to thank Clay for rewarding such creativity: the cover letter of Rocheleau's paper is marked "A++". . . **GW**

As they wheeled her into the room her hopes began to fade. She had been praying that this place would be different from all the others. The last room had been so cold. Not only in temperature; no one had even attempted a conversation the entire eight months she had been there. This new room seemed to be a copy of the last, and all the others she had been in.

They placed her in a corner, and after plugging in all of her tubes and wires, they left. It was terribly quiet and dark.

Suddenly she began to receive something from someone across the room. She was absolutely ecstatic. Someone was trying to communicate with her. The language was a bit strange, it was some form of output statement:

PRINT*,'What is your name?'

It was sort of hard to understand yet they were characters, her specialty, and after a bit of interpretation, she decided upon a method of replying. She had no PRINT statement in her memory, but she did have a trick up her circuit board. She sent her interpreter the instruction:

(CONS('(My name is LISP. What is yours?)))

As the other received her message, she could almost sense a chuckle. Soon she received his reply:

PRINT*,'My name is FORTRAN. Why must you com-

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municate in such a strange way? Don't you have input and output commands?'

She felt a bit embarrassed, yet she knew that she had many advantages over this FORTRAN fellow. She replied:

(CONS('(No, I don't have input or output commands. I have to use this CONS instruction with quotes to get something printed out. And I have other instructions to use as input instructions.)))

His reply upset her greatly:

PRINT*,'Ha, how cumbersome. I bet you can't even handle a simple addition without some complicated function call. Well anyway, I'll grace you with a little knowledge about myself. I was one of the world's first high-level programming languages. And today I am probably the most widely used language for programming of scientific and engineering computations.'

She sat for a few nanoseconds, organizing her cut-down:

(CONS('(All right, blowhard, listen to this; I and my various dialects are the primary languages in at least two areas of computer science: symbolic computation and artificial intelligence, which are concerned with programs that perform tasks that humans say require intelligence. Has anyone ever said you have intelligence? I bet not!)))

PRINT*,'Intelligent! How can you even consider yourself intelligent if you can't deal with numbers. I mean numbers make the world go around. Look, even your insides are numbers—all zeros and ones, and you don't even understand them. I bet you can't deal with decimals, or even take the square root of a number—real or integer. You're useless.'

Quickly she replied:

(CONS('(No, I can't take the square root of a number, but I can do quite a bit with numbers. Just take a look at this, these are some more of my functions:

(PLUS X_1. . . . $.X_n$)	= $X_1 + \ldots + X_n$
(DIFFERENCE X Y)	= $X - Y$
(MINUS X)	= $-X$
(TIMES $X_1 \ldots X_n$)	= $X_1 \times \ldots \times X_n$
(ADD1 X)	= $X + 1$
(SUB1 X)	= $X - 1$
(QUOTIENT X Y)	= $X \div Y$
(LESSP X Y)	= T if $X < Y$ else NIL
(GREATERP X Y)	= T if $X > Y$ else NIL
(ZEROP X)	= T if $X = 0$ else NIL
(NUMBERP X)	= T if X is a number else NIL
(LENGTH X)	= Length of list X

They may not be as simple to understand as your method of manipulating numbers, but remember this: numbers are just a minor part of my abilities. Why, unlike you, I can even distinguish between a character and a number with my NUMBER function.

I realize that you are very graceful when it comes to dealing with numbers, but when it comes to character manipulation, a programmer would be crazy to use you. With me, the programmer can easily deal with characters and do a little with numbers if need be. You see, I'm not quite so one-sided as you are.)))

PRINT*,'OK Miss LISP, how about subroutines? They're simple. All I have to do after the END statement (I do hope you understand everything so far) of the main body is have the programmer write SUBROUTINE Name (parameter list). Below this all he has to do is write a subprogram that will be executed just like a regular program, when, in the calling program, the instruction CALL Name (argument list) is encountered. When the execution of the subroutine is finished, a RETURN statement returns control to the statement following the CALL statement in the calling program. The parameters in the parameter list are reference parameters, using the chaining, the copying, or the value/result method. Why, my subroutines can even call other subroutines if they want to. . . . I'm waiting for your response!'

(CONS('(I love the way you quickly changed the subject—away from letters and numbers. But, OK, here's my response: I will add to my argument of input and output while describing my "subroutines," which I call Procedures. I don't need explicit input and output statements

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because "data" is provided in the form of arguments in procedure calls and because the value produced by a procedure called at the top level is automatically output by my interpreter.

I have taken a good look at your basic structure—Blah! At my top level, your main program, I have no need for variable declaration, assignments, loops, tests, etc. This is so because usually the first environment where such things are meaningful is the environment established by a procedure called from my top level.

To show you how I "call" a procedure, I must first say that nearly all of my commands are procedure-related. And all of my procedures return a value—thus, they are function procedures.

First I define a procedure, then I call it—just the opposite of your goofy subroutines. To define a procedure, I merely say:

LISP PROCEDURE Name(parameter list)
Body

where the body is much like the body of your subroutines. It is simply instructions to perform the task of the procedure. Some of the instructions can even be Procedures themselves.

As far as calling goes, I don't even have to say Call. All I have to do is write the name of the procedure along with its parameter list, for in essence my procedures are functions.

Name(parameter list)

This is all that is needed. The parameters are usually values. But I can pass arguments in the unevaluated form—Name Parameters. And my procedures can call themselves: this is called recursion, the all-important function that you can't even handle. You're nothing but an old man that's constantly being updated. They'll soon phase you out. No recursion—ha ha!)))

PRINT*,'OK, so I am old, but you ain't no spring chicken yourself. I have been doing a bit of research while you were babbling. We were both invented in the late '50s. So don't talk to me about old.

Oh, and there's one little thing you left out—how about Global Variables? You don't even have such a thing. Why, when I call a subroutine, I can have a COMMON statement in both the calling and the called routines, in which there are variables which are global to the called routine. They can be changed if need be by the called routine, or they can just be used in evaluations. These changes, if any, affect the values in the calling routine. Why, I can even name my common statements, like this:

COMMON / Name / variables

This way, different subroutines can have different globals with their calling routines. Can you top that????'

(CONS('(I sure can . . .)))

Suddenly the lights came on. The humans were back. Oh well, their talk would have to wait. Maybe this place wouldn't be so bad after all. ■

Logo for Personal Computers

Harold Nelson, Technical Editor

The imminent release of not one but *two* versions of the Logo language for personal computers may be one of the most exciting software developments of the year.

The Logo programming language was developed at the Artificial Intelligence Laboratory at MIT (Massachusetts Institute of Technology). According to the Logo Project's originator and driving force, MIT Professor Seymour Papert, "Logo is the name of a philosophy of education in a growing family of computer languages...."

In the same passage, Professor Papert is quick to point out that Logo is not merely a children's language, although since its development over twelve years ago it has always been intended to facilitate discovery learning by young children. In fact, it represents a kind of "Copernican revolution." Rather than the child being programmed by the computer (as with computer-aided instruction), the child learns by *teaching* the computer—and has a good deal of fun in the process. In the past, this has been the overriding purpose of the Logo Project. However, Professor Papert states: "An example of a powerful use of list structure is the representation of Logo procedures themselves as lists of lists so that Logo procedures can construct, modify, and run other Logo procedures." (*Mindstorms: Children, Computers and Powerful Ideas.* New York: Basic Books Inc, 1980, page 217.)

Apple Logo and TI Logo are the first versions of this language that are intended for use with personal computers. TI Logo was developed for the Texas Instruments 99/4 computer, while Apple Logo runs on the Apple II or Apple II Plus computer. Each is a descendant of earlier implementations written in LISP and Pascal for larger computers, and this heritage is evident in both versions of the language.

TI Logo

The first "draft" of Logo for the TI 99/4 was prepared by the Logo Project at MIT. Texas Instruments modified this draft according to its priorities and has done some impressive code compression in order to increase available memory for the production version of TI Logo.

Hardware for TI Logo

In addition to the TI 99/4 computer and a color monitor, memory expansion (from 16 K bytes up to 48 K bytes) and the language in EPROM (erasable programmable read-only memory) are the only requirements for running the prototype of TI Logo. In the prototype, both memory expansion and the language are contained in an actual black box (see photo 1, inset).

TI Logo has two production versions. The currently available version requires a disk controller, a 5-inch floppy-disk drive, a 32 K-byte memory expansion unit, and a TI Logo command module or ROM (read-only memory) cartridge. The second version, scheduled for release later this year, will require only the memory expansion unit and the command module (see photo 1).

Features

TI Logo can perform arithmetic operations on integers from −32,768 thru 32,767, and can generate random integers from 0 thru 9, perform basic logical operations, and evaluate logical relationships. It can also assign numerical values to words (values to variables), assign names to numbers (so that something can be called by name instead of number), and it has functions for structuring and modifying lists. In addition, there is a fine program editor for writing and modifying procedures (Logo programs).

Other Logo features in Texas In-



Photo 1: *The TI Logo prototype (inset), including memory expansion, is contained in the black box under the monitor and behind the TI 99/4 computer. The final production version of TI Logo, which should be available later this year, will consist of a 32 K-byte memory expansion unit and a solid-state command module. (Photo courtesy of Texas Instruments.)*

struments' version include powerful yet easy-to-use graphics capabilities that employ a *turtle* for drawing and thirty *sprites* for creating dynamic displays.

The Turtle

One of the best-known features of Logo is turtle graphics, or the line-drawing turtle—a small triangle on the video display (see photos 2 and 3). A variety of simple instructions move the turtle, tell it to face a certain direction, move it a given distance, and instruct it to draw, not draw, or erase a line.

Early MIT versions of Logo actually controlled a floor robot that resembled a turtle. This floor turtle had a pen that could be raised or lowered for tracing the path that the turtle was instructed to follow. Originally, the state of the art made use of a mechanical robot easier than computer graphics When young children were involved, the floor turtle also seemed to facilitate the transition to using the screen turtle. (The significance of turtle graphics has been recognized outside MIT for some time. For example, a subset of Logo, called Turtletalk, has been included in the Smalltalk language designed by Alan Kay for Xerox. Turtlegraphics is also a program in the library of the Apple version of Pascal.)

TI Logo has a screen turtle that can be controlled by simple primitive instructions (see text box on turtle primitives). These *primitives* can be used for immediate turtle instructions or to create *procedures* (sequential lists of instructions) which define new instructions.

An important feature of TI Logo is that while all primitives can be spelled out in full, many can be abbreviated to two-letter instructions (eg: CS can be used anywhere in place of CLEARSCREEN). Such abbreviations can make Logo more accessible to such nontypists as the very young or the handicapped.

Sprites

The inclusion of thirty sprites and



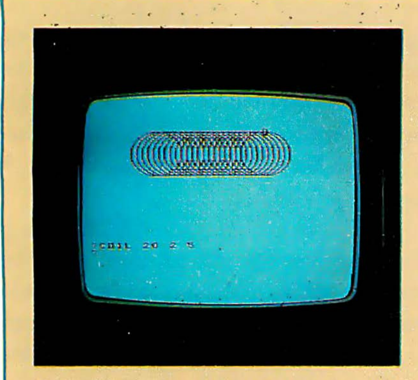


Photo 2: *The turtle, shown at the top of the rightmost circle, has just completed a series of slightly displaced circles in order to produce this coil, or slinky-type, figure.*



Photo 3: *This equilateral triangle is produced by lifting the turtle's pen, moving the turtle seventy steps forward (toward the top of the display), and then lowering the pen. At this point the turtle stops and waits for further instructions. It is instructed to turn 150° to the right and move forward seventy-five steps—this produces the right leg of the triangle. The turtle waits again. It is told to repeat the following sequence twice: turn right 120° and go forward seventy-five steps. This causes the turtle to draw the base and left leg of the triangle. The turtle is then told to raise its pen, return home (to the center of the drawing pad), and put its pen down. Since these instructions are not written in a procedure, it is necessary to reenter the entire sequence each time the triangle is to be reproduced.*

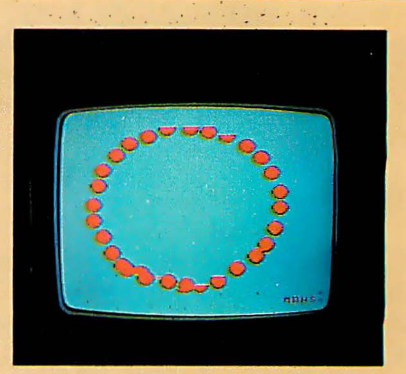


Photo 4: *In this demonstration procedure provided by Texas Instruments, all thirty sprites have been told to carry the ball shape and move away from the center (home) position, each in a different direction.*

dynamic sprite graphics is unique to TI Logo. As shown in photos 4 and 5a, sprites are TI Logo "beings" (software constructs) that assume various shapes and colors and move in a number of directions at different speeds. (See also listing 1.) Of themselves, sprites possess none of these "physical" characteristics—these must be given to them, once again, by use of simple primitives (see text box on sprite primitives).

Sprites can assume (carry) any one of twenty-eight possible shapes. The first six shapes (turtle, truck, plane, rocket, ball, and box) are predefined in TI Logo (see photo 6). The remaining twenty-two shapes must be user-defined.

A new shape can be created, or an existing one modified (you can change the six predefined shapes), by calling a 16 by 16 square MAKESHAPE grid (see photo 5b) and blacking out the desired shape. Each square of the grid represents one pixel (picture element) on the video display. The shape is formed (blacked out) by moving the cursor from square to square within the grid. Once a shape has been defined, any or all of the sprites can carry that shape.

(Displaying sprites seems to be a major capability of Texas Instruments' TMS9918A Video Display Processor. TI has released the TMS9918A, and the unit is beginning to appear in products from independent manufacturers. See "Video Display Processor Simulates Three Dimensions," by Karl Guttag and John Hayn, *Electronics*, November 20, 1980, page 123.)

Characters

TI Logo also allows you to define (or redefine) alphanumeric characters and static designs by using any of the 256 8 by 8 square grids, called *tiles*. Letters, numbers, and other keyboard characters are predefined tiles, but they can be changed. If the predefined keyboard characters are modified (eg: made lowercase), the modified character appears when the appropriate key is typed.

New characters or designs can be defined and placed anywhere on the display screen (see photo 5c). While tiles can be located anywhere on the screen, they cannot move about as can shapes that are carried by sprites.

You can assign colors to tiles and use them in either the turtle or sprite modes to form titles, explanations, or parts of "pictures."

Procedures

Procedures can be considered as either Logo programs or definitions of words that, once defined, can be used like primitives. Procedures are lists of instructions made of primitives and/or the names of previously defined procedures (see photos 7a and 7b, and listings 1, 2, and 3). Resident or defined shapes, colors, and movements can be assigned to sprites in procedures. The turtle can be instructed to draw figures by simply entering the name of a procedure.

It is often easier to define procedures, whether they contain instructions for the turtle, the sprites, or nongraphic operations, rather than enter the individual instructions needed to carry out such tasks. One reason is that several sophisticated programming techniques become quite simple in Logo. It's possible to *nest* level upon level of procedures by having one procedure call another which, in turn, can call another, and so on. A nested procedure is called by entering its name as an instruction in the procedure being written. *Iteration* is accomplished by merely having the procedure repeat a list of instructions a certain number of times. *Recursion*





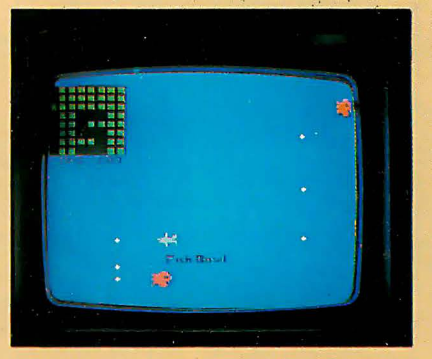


Photo 5: *The shapes and characters used in the FISHBOWL (photo 5a) were specifically defined (see listing 1 for the procedures). Shapes are defined by blacking out the desired shape on a 16 by 16 square grid (photo 5b). Characters are similarly defined on an 8 by 8 grid (photo 5c).*

is a simple matter of using the name of the procedure being defined as an instruction in that procedure—the procedure then calls itself from within itself.

It is also possible to construct a procedure so that it modifies itself. This can be done by having the procedure change the values of local variables and/or by having it define new, or modify already-nested procedures. This type of recursion causes the procedure to produce a different effect at each recursive level—the procedure performs its task, changes itself, performs its modified task, etc. Listing 2 demonstrates how these powerful concepts and techniques become virtual child's play with Logo.

In addition to the ease of writing procedures and all that can be learned in the process, there is another advantage to working with procedures rather than immediate instructions. After entering all of the individual instructions for the turtle or sprites, it would then be necessary to enter the entire sequence each time that activity was to be performed. If the instructions are included in a procedure, it's simply a matter of entering the procedure's name to have the activity performed. In addition, procedures, along with user-defined shapes and characters, can be saved for future recall. In the TI Logo prototype this is done on cassette. In the production versions it will be possible to do this on disk—a preferable method with regard to both speed and reliability. The production versions of TI Logo have hard-copy capability via a thermal printer. In some settings this can be extremely useful.

The Editor

TI Logo has a full-screen, real-time edit mode that is extremely helpful for writing, modifying, and debugging procedures. While in the edit mode, the cursor can be moved anywhere in the displayed text to

Listing 1: *The FISHBOWL procedure turns the video display into a simulated aquarium (see photo 5a) with fish swimming in various directions and bubbles rising to the surface. FISHBOWL first calls TITLE, which places the tiles (see photo 5c) containing the specially designed letters of "Fish Bowl" at the center bottom of the display. The FISHBOWL procedure then tells the background (BG) to set its color (SC) to dark blue (4), and calls the procedures FISHRIGHT, FISHLEFT, BUBBLES, and SHARK. These four procedures assign shapes, colors, and motion to various sprites. For example, FISHLEFT tells three sprites (4, 5, and 6) to carry the shape (7) of a fish swimming to the left (see photo 5b), and sets different colors, headings (SH), and speeds (SS) for each sprite. In BUBBLES, the SETX primitive is used to horizontally fix the two columns of bubbles. The numbers input are the x coordinates of the desired columns.*

```
TO FISHBOWL
TITLE
TELL BG SC 4
FISHRIGHT
FISHLEFT
BUBBLES
SHARK
END

TO TITLE
CS
PUTTILE 12 20 100
PUTTILE 13 20 101
PUTTILE 14 20 102
PUTTILE 15 20 103
PUTTILE 16 20 104
PUTTILE 17 20 105
END

TO FISHRIGHT
TELL [1 2 3] CARRY 6
TELL 1 SC :RED SH 95 SS 20
TELL 2 SC 8 SH 75 SS 18
TELL 3 SC :YELLOW SH 105 SS 16
END

TO FISHLEFT
TELL [4 5 6] CARRY 7
TELL 4 SC :ORANGE SH 273 SS 19
TELL 5 SC :GREEN SH 265 SS 21
TELL 6 SC :LEMON SH 279 SS 17
END

TO BUBBLES
TELL [7 8 9] CARRY 8
EACH [SC :WHITE SETX -50]
EACH [SH 0 SS 3*YN]
TELL [10 11 12 13] CARRY 8
EACH [SC :WHITE SETX 70]
EACH [SH 0 SS 2*YN]
END

TO SHARK
TELL 14 CARRY 10
SC :GRAY SH 271 SS 40
END
```

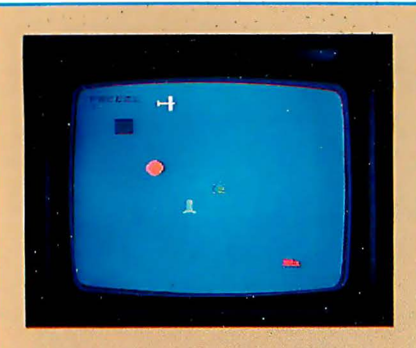


Photo 6: *In addition to these six predefined shapes in TI Logo, the user can define as many as twenty-two additional shapes. Each of these can be carried by any or all of the sprites.*

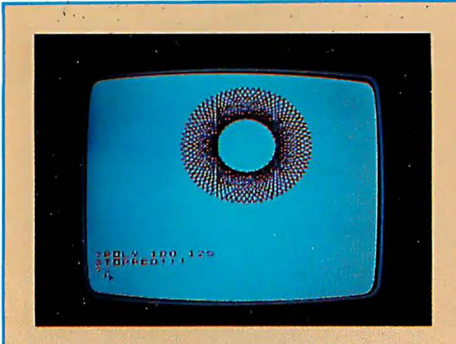




Photo 7: *The pattern in photo 7a is produced by stopping the procedure, shown in the edit mode in photo 7b.*

Turtle Primitives

The basic turtle primitives are virtually identical in TI and Apple Logo. Differences are noted in parentheses, as are acceptable abbreviations. All primitives can be fully spelled out and most can be entered as two-letter abbreviations.

The turtle mode is entered by the instruction TELL TURTLE (DRAW in Apple Logo). This places the triangular-shaped turtle at the center of the "drawing pad." In TI Logo this position is the origin of a coordinate system whose horizontal (x) axis goes from −128 to 128, whose vertical (y) axis ranges from −96 to 96.

There are four text lines under the pad for entering instructions and receiving messages. The Apple version is almost the same in the split-screen turtle mode (actually the horizontal axis goes from −140 to 138). This is normal turtle mode. Apple Logo, however, also offers a full-screen turtle mode that allows the turtle to draw on the entire pad but eliminates the text lines (see photos 9 and 10a).

Both versions employ the following instructions for moving the turtle:

FORWARD (FD) number *BACK (BK)* number	*The* number *represents the number of turtle steps that the turtle is to move.*
RIGHT (RT) angle *LEFT (LT)* angle	*The* angle *represents the angle, in degrees, that the turtle is to turn.*

It is possible to move the turtle anywhere on the drawing pad and trace virtually any shape with these instructions.

More interesting figures can be obtained by having the turtle draw only part of the time. The following commands, in both versions, control the turtle's pen:

PENDOWN (PD): Causes the pen to leave a trace of the turtle's path (the pen is down when the turtle mode is entered).

PENUP (PU): Allows the turtle to move about without leaving a trace.

PENERASE: Causes the turtle to erase a line it has drawn if the original path is retraced.

PENREVERSE: Instructs the turtle to draw lines where there are none and erase lines where they are present.

HOME sends the turtle back to the center of the drawing pad. CLEARSCREEN (CS) in TI Logo erases all drawing and text and returns the turtle to the home position. DRAW does almost the same thing in Apple Logo but it does not erase text.

In order to exit the turtle mode, enter the instruction NOTURTLE (NODRAW in Apple Logo). This will return you to the Logo monitor.

change, delete, or insert characters, words, or entire lines. It's also possible to move lines up or down and merge them with other lines.

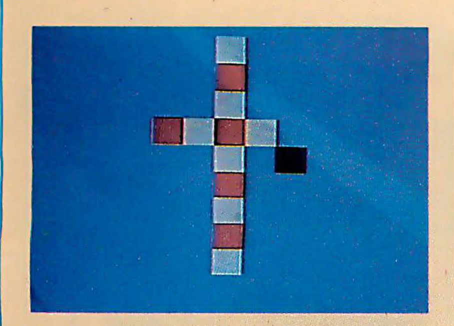
The editor in the production version of TI Logo is automatically activated for writing procedures. (The prototype does not have this feature.) Several features can be written in the edit mode and all of them entered into memory by exiting the edit mode. One advantage to writing procedures in the edit mode is the ease with which you can change and correct the procedure as it is being written.

You can also use the editor's capabilities as a basic text editor. This is an important feature, since learning to write with a text editor relieves the tedium of making pencil-and-paper corrections and revisions.

Limiting Features

The video hardware of the TI 99/4 does not allow more than four sprites carrying shapes to be displayed on a horizontal row at one time (see photos 8a and 8b). If a fifth sprite is placed on the same row, the first one disappears, and so on. The process is reversible, so as soon as the newcomers move on, the original residents begin to reappear. Once you are aware of this problem, you can work around it.

An annoying occurrence in TI Logo is that the turtle sometimes runs out



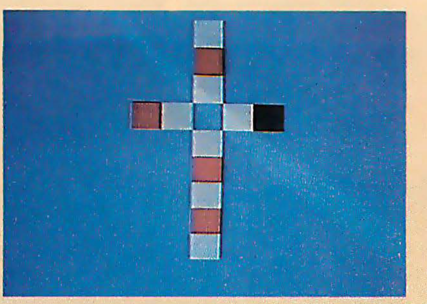


Photo 8: *These photos illustrate a slight problem caused by the TI 99/4's video hardware when running Logo. As long as there are no more than four shapes in a horizontal row, there is no difficulty (photo 8a), but as soon as a fifth shape is moved onto a row (the black square in photo 8b), the first shape in that row disappears (the red square that was at the center in photo 8a is gone in photo 8b). The first shape reappears when the fifth shape is moved to another row, so there can never be more than four visible shapes in a row at one time.*

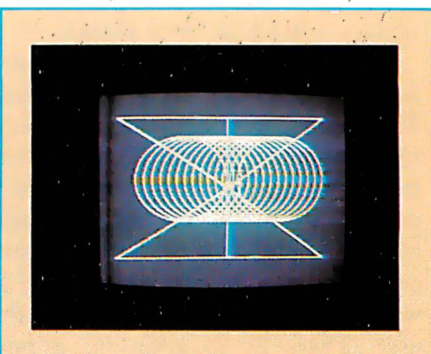


Photo 9: *Apple Logo's turtle graphics can produce interesting figures from simple procedures. Straight lines can be drawn by setting the x and y coordinates. The turtle will draw a straight line from its present point to the point you have set. This photo and photo 10a show the full-screen graphics feature of Apple Logo.*

of lines. At this point, the turtle stops in its tracks, the procedure halts, and the following message is printed:

NO MORE LINES

Apparently, workspace allocations have to accommodate both sprite and turtle graphics modes. Some tradeoff was necessary, and this message appears to inform you that the workspace (memory) allocated for graphics in the turtle mode has been used up.

Apple Logo

At present, the 5-inch disk version of Logo for the Apple II and Apple II Plus computers is still under development at MIT. (For convenience, we refer to this version as "Apple Logo," as does the Logo Project staff. To our knowledge there is no connection with Apple Computer Inc.) Representatives of MIT and the National Science Foundation, which funded portions of the Logo Project, are involved in discussions concerning distribution rights for Apple Logo. This issue should be resolved soon, and Apple Logo will, it is hoped, be available this summer.

This review is based on a preproduction prototype, and in fact, an updated prototype that will include color is being completed. This feature will allow you to choose the color of the display background and the lines drawn by the turtle.

Apple Logo has three modes: a nongraphics mode, a graphics (turtle) mode, and an edit mode—but no sprites. However, the Apple version does have much more power in the other modes than TI Logo.

Hardware for Apple Logo

An Apple II or Apple II Plus computer with 48 K bytes of memory, one disk drive, and an Apple Language Card are all that is needed to run the Apple version of Logo.

Nongraphic Features

Apple Logo can handle *floating-point* as well as integer arithmetic. It also accepts and outputs numbers (when large or small enough), in exponential notation. For example, 2.7E3 can be used in place of $2.7 \times 10^3 = 2700$, and −4.3N4 can

Sprite Primitives

Some of the primitives used to instruct the sprites (available only in TI Logo) are as follows:

TELL sprite number(s): *Gets the attention of the sprite(s) that you wish to address. You can address one or any combination of sprites from 0 thru 29. To talk to all thirty sprites, the phrase :ALL (read "dots ALL" in Logo jargon) is used in place of a number.*

CARRY shape: *Tells the sprite(s) which shape to assume. Shapes can be identified either by name or number.*

SETCOLOR (SC) color: *Identifies, either by name or number, the color of the shape being carried.*

SETHEADING (SH) number: *Gives the sprite(s) the direction to travel. The* number *entered corresponds to a compass heading.*

SETSPEED (SS) number: *Tells the sprite(s) how fast to move.*

The displays produced with these five instructions can be amazing, especially when multiple instructions are combined in procedures.

A few other primitives can also be used in interesting ways. HOME causes all active sprites to go to the center of the display screen but, if they have headings and speed, only momentarily. FREEZE stops all active sprites and holds them in place. They will not resume movement until THAW is entered.

Sprites will also respond to the FORWARD (FD), BACK (BK), RIGHT (RT), and LEFT (LT) primitives as used in the turtle mode.

replace $-4.3 \times 10^{-4} = -.00043$.

Apple Logo can also return the sine and cosine of an input in degrees. This means, in effect, that it has full trigonometric capability. The other trigonometric functions can be easily defined in terms of the sine and cosine. Apple Logo can return a random integer in the range of 0 to $n-1$, where n is an integer input by the user. There is, in addition, a randomizing feature to ensure that each sequence of random numbers will be unique.

Apple Logo has features for evaluating logical relationships, assigning values to variables, words to numbers, and working with list structures. The Apple version of Logo also has provisions for going from Logo to the Apple monitor, calling machine-language subroutines, and determining the current amount of free workspace in Logo. (Texas Instruments omitted similar features in order to save memory space.) And it's worth pointing out that the primitives that instruct the turtle are similar in both the Apple and the TI versions of Logo.

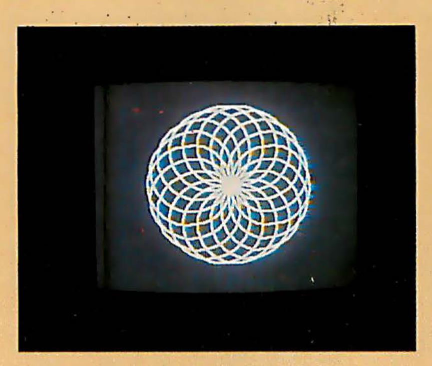




Photo 10: *The SPINSLINK figure (photo 10a) is the result of the simple five-line SPINSLINK procedure (shown in the edit mode in photo 10b) that calls the three-line RCIRCLE procedure which, in turn, calls the RCP procedure. Each procedure is nested in the one listed below it. Note the use of floating-point arithmetic in RCP, the use of iteration in RCIRCLE, and the use of recursion in SPINSLINK (it calls itself). (The procedures are taken from the draft of the Apple Logo manual prepared by Harold Abelson.)*

Turtle Procedures

The draft of the Apple Logo manual, by MIT Professor Harold Abelson, contains over twenty-five pages of turtle geometry projects of rapidly increasing complexity (see photos 9, 10a, and 10b). This manual also contains some interesting discussions of recursion—in fact, the author suggests a level of recursion that can be used to have the turtle draw a "binary tree" (see listing 3).

The additional mathematical capabilities of Apple Logo, as compared with the TI version, can be used to increase the power of turtle procedures, even though these mathematical features are not graphics features *per se*. That is, the floating-point, trigonometric, and randomizing features can be employed to give straightforward instructions to the turtle that will result in figures otherwise difficult, if not impossible, to produce.

The Editor

The Apple Logo editor functions in essentially the same manner as the production-version TI Logo editor. As soon as you begin to write a procedure, you're automatically in the edit mode. Therefore, all of the editor's features are available whenever procedures are being written. It is also possible, as with TI Logo, to employ these features as a text editor.

There is, however, one confusing sidelight. The command to abort a procedure (rub out what has just been written and exit the edit mode) in Apple Logo is very nearly the same command used in TI Logo to enter the procedure into memory and exit the editor. This could cause considerable confusion if you work with both versions side by side.

An Annoying Feature

If the turtle tries to draw beyond the drawing pad in the turtle mode of Apple Logo, everything stops and you are told that the turtle just went OUT OF BOUNDS. If you are in the process of modifying a procedure to fit onto the pad, this is quite a nuisance. In the TI version, if the turtle leaves his pad he simply *wraps* around the display, and the procedure continues to execute. This approach seems preferable, because you can visualize the finished product. (In the large-machine versions of Logo you can choose between wrapping and not wrapping—an ideal arrangement.)

Conclusions

Both personal computer versions of Logo are exciting, valuable products. Seymour Papert has said on more than one occasion that Logo provides easy access to very powerful ideas, but the question remained—would this be true of Logo designed for small personal computers? The answer, relative to both versions, is clearly affirmative, whether the user is a young child, a physically handicapped individual, or an adult who discovers computing for the first time.

It's difficult to find anything to criticize in either product. Given their common background of over ten years of development and testing in the Logo Project at MIT, such a situation is not hard to understand. Still, a few items in each version might have been handled differently.

One such example occurs when you attempt to use the Apple and TI Logo nongraphics instructions in the immediate mode. These functions do not simply return a value. For example, in TI Logo:

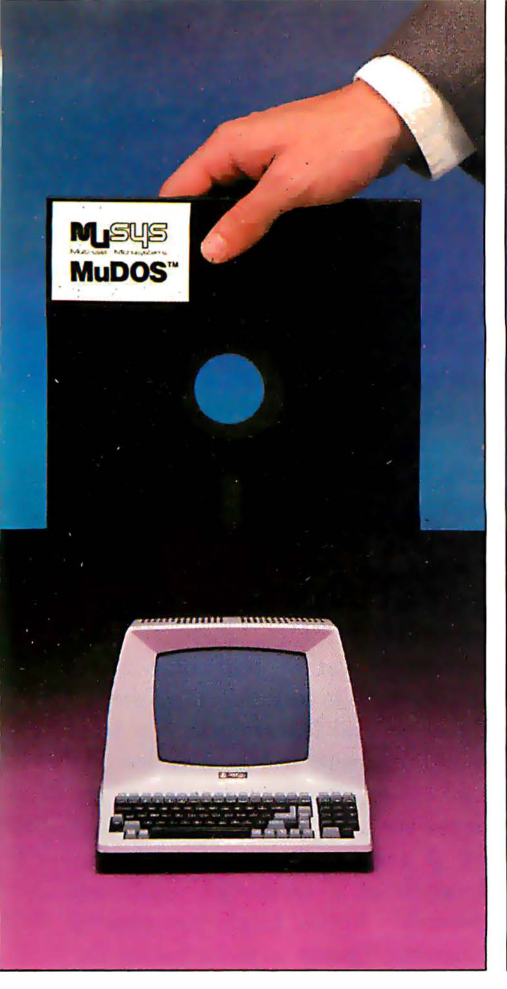
3+4

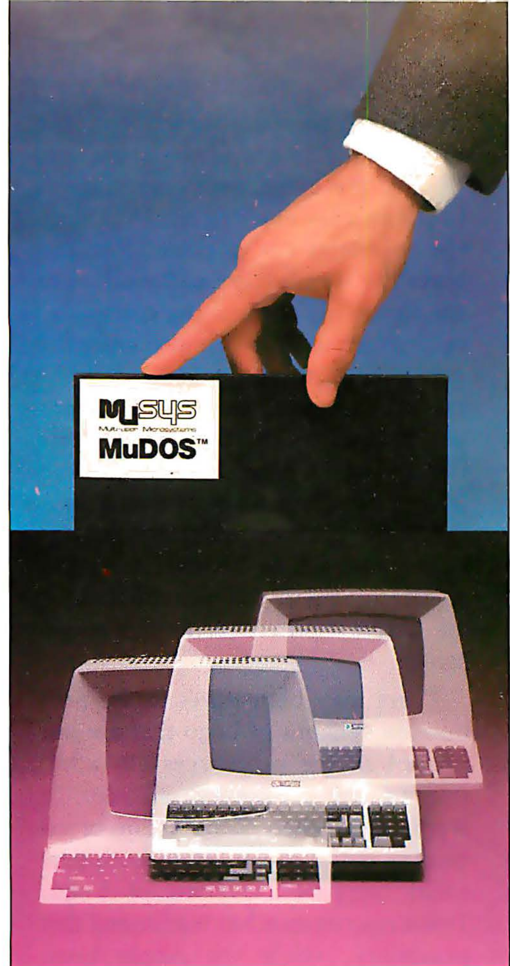
returns:

TELL ME WHAT TO DO WITH 7

It will not return just the value 7. Similarly, in Apple Logo:

SIN 30







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Circle 253 on inquiry card.

returns:

```
YOU DON'T SAY WHAT TO DO
WITH .5
```

The reason for this, apparently, is that these functions are intended for use in instructions in procedures where the value returned will be used for a variable. It would be useful, however, if these functions could be used immediately, and if they returned only the appropriate values: they could then be used more easily for mathematical or logical evaluations, either in planning procedures or for other purposes.

If you type PRINT in front of the statement to be evaluated, only the value is returned. For example:

```
PRINT 3+4
```

will return only the value 7. Still, it would be useful to obtain this kind of return without typing PRINT, especially when you are not "talking" to sprites or the turtle.

Another inconvenience occurs in TI Logo when you have active sprites on the screen and want to go to the turtle mode. There is no easy way to get the active sprites off the video display. While you can go from the turtle mode to the sprite mode and remove the turtle with everything it has drawn (by entering NOTURTLE), the reverse is not possible. You can leave the sprites there and work with the turtle, but the moving sprites can be distracting. You can also enter the necessary instructions to remove the colors, shapes, speeds, and headings of the sprites, but this can be time consuming. A third alternative is to leave Logo and then restart it. This is often the quickest solution. In any case, it would be helpful to have a single command that would remove all active sprites from the video screen.

There may be features in the production versions of Logo that are not present in the prototypes—in addition to the possibility of color in Apple Logo, there is discussion of including music capability in both personal computer versions of Logo. Texas Instruments has mentioned this possibility, while the Apple Logo documentation already contains some explanation of how to use the music features, even though they are not present in the prototype.

The prototypes of Apple and TI Logo are currently being used in preschool through high school classrooms (see *onComputing*, Summer 1981, for details) on a "pilot project" basis, and evidence of its value to students is growing rapidly. This evidence deals not only with amount of material learned, but also with a heightened self-awareness and self-esteem derived from the student controlling a powerful machine and thus his or her own learning. It seems inevitable that Logo will become a forceful learning tool, both in the school and in the home.

Having acquired at least a passing familiarity with these two Logo implementations, I see them as complementary, rather than competitive. Anyone who is seriously interested in education and learning on any level should examine both versions. TI Logo easily attracts user interest (the sprites are a definite attention-getter) and it encourages fundamental exploration of a variety of significant concepts. Apple Logo provides a somewhat deeper exploration of the same concepts. The development of Logo for other popular personal computers such as the Radio Shack TRS-80 and Atari will probably not be far behind. ■

Listing 2: *The COILGROW procedure has CIRCLEMOVE and CIRCLE nested within it. CIRCLE, in turn, is nested in CIRCLEMOVE. Both COILGROW and CIRCLE employ iteration by repeating the instructions in the brackets. COILGROW is a recursive procedure—it calls itself. COILGROW produces a coil consisting of connected circles of increasing diameter. The procedure is run by entering its name and values for the variables NUMBER, DISTANCE, and ANGLE. (The 360/(:ANGLE) in CIRCLE causes an interesting "bending" of the coil, since it returns an integer that may be slightly more or less than the number of iterations required to produce an exact circle. HIDETURTLE, in the CIRCLE procedure, speeds up drawing since the turtle itself need not be redrawn at each "step." SHOWTURTLE causes the turtle to reappear.)*

```
TO COILGROW :NUMBER :DISTANCE :ANGLE
REPEAT :NUMBER [CIRCLEMOVE :DISTANCE :ANGLE]
CIRCLE :DISTANCE :ANGLE
MAKE "ANGLE :ANGLE-3
COILGROW :NUMBER :DISTANCE :ANGLE
END

TO CIRCLEMOVE :DISTANCE :ANGLE
CIRCLE :DISTANCE :ANGLE
FORWARD :DISTANCE
END

TO CIRCLE :DISTANCE :ANGLE
HIDETURTLE
REPEAT 360/(: ANGLE) [FORWARD :DISTANCE RIGHT :ANGLE]
SHOWTURTLE
END
```

For More Information

To add your name to the Apple Logo mailing list, write: Apple Logo, The Logo Project, 545 Technology Square, Cambridge MA 02139. For $1 they will also send a bibliography of papers produced in conjunction with the project.

For information on TI Logo, write: TI Logo, Texas Instruments Inc, Corporate Engineering Ctr, 12860 Hillcrest Wing E M/S 376, Dallas TX 75230.

Listing 3: *MYSTERY requires that an integer be input for the variable NUMBER. It then prints the integers 1 thru NUMBER in an unexpected order: the STOP in the recursive procedure produces the MYSTERY effect; when the technique is used in a V-drawing procedure, the turtle can draw a "binary tree."*

```
TO MYSTERY :NUMBER
IF :NUMBER=0 STOP
MYSTERY : NUMBER-1
PRINT :NUMBER
END
```



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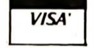
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Recently I was at a local electronics store looking at DVMs (digital voltohmmeters). I didn't want to buy one, but, like looking at new cars, I wanted to reestablish the cost-effectiveness of what I already owned.

Most of the meters in the showcase were 3½-digit units with five or more ranges and many ancillary functions. The sales pitch for every one sounded alike.

While not trying to be cute, I stopped the clerk in midsentence and asked if he had any DVMs that "talked." He completely ignored the question. I had to interrupt him twice to get his attention, and even then, he thought I was being difficult.

Eventually, he said that he had no talking DVMs and never expected to see any. Even though I anticipated his answer, I was testing his response to the idea. Considering that we now have talking toys, talking hand-held DVMs shouldn't sound that strange. In fact, such use would be a relatively minor application of synthesized speech. Someday they will be very common.

While I wouldn't consider this salesman a total loss, there are some people who have to go to Missouri to believe the state exists. I trust, however, that you have an open mind to new technology.

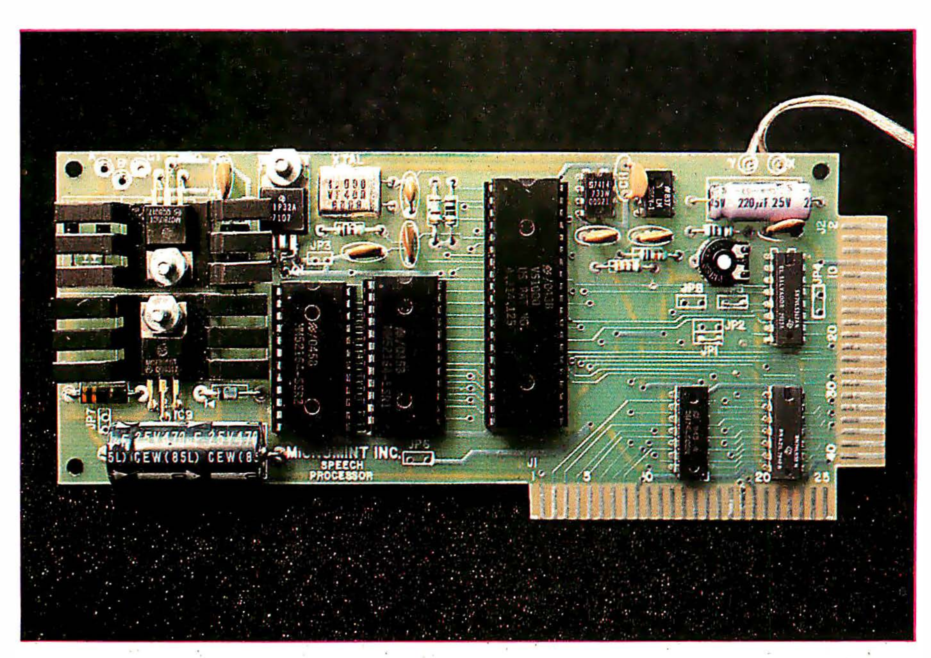


Photo 1: *Assembled Micromouth speech-processor board. The 40-pin integrated circuit is the MM54104 speech processor, and the two 24-pin packages are 64 K-bit ROMs, which contain 144 digitized expressions. The 40-pin edge connector on the right is plug-compatible with the Radio Shack TRS-80 Model I, and the 50-pin edge connector on the bottom is plug-compatible with the Apple II. The heat sinks shown in the photo are not generally required but were included on this particular unit for testing.*

Cost-Effective Speech Synthesis

Advances in the production of high-density LSI (large-scale integrated) circuits and new techniques to synthesize speech have reduced the cost of voice-output systems dramatically. Attaching a speech synthesizer to your computer is now as reasonable financially as adding any other peripheral device.

The cost of a synthesizer is a function of the number of words the synthesizer can speak. Limited-vocabulary synthesizers, such as the TMS0280 unit in the Texas Instruments Speak & Spell toy or any others that have their vocabulary stored totally in ROM (read-only memory), are generally less expensive. Speech interfaces using phoneme synthesis, such as the Votrax SC-01, usually require the help of a computer program running on an external processor to generate extensive voice output. The added complexity makes this type of synthesizer more expensive. Of course, a phoneme synthesizer can have an unlimited vocabulary by using a text-to-speech program running on the external processor.

This article describes the construction of a cost-effective limited-vocabulary voice-synthesis speech-processor board called the Micromouth. It uses the new Digitalker DT1050 integrated circuit set from National Semiconductor, which has a stored vocab-

Digitalker is a registered trademark of National Semiconductor Corporation.

ulary of 144 expressions. For about $120, you can build this board and add voice output to monitoring functions, computer games, and calculations. It can say "The time is 6:40 pm" and "Number 4 is set at 6.35 volts" just as easily as "Control error..." or "Danger...a star is on the left at 8.2 million meters." While a limited-vocabulary synthesizer may never have appealed to you before, I am sure the low price and simple system integration of this speech interface will spark your interest.

The Micromouth speech-processor board I am presenting is plug-compatible with the Apple II and Radio Shack TRS-80 Model I computers. (It can be used with the TRS-80 Model III with an adapter cable.) It is signal-compatible with other microcomputers, such as the Digital Group product line or the Heath H-8, and can be connected to any computer with an 8-bit parallel I/O (input/output) port, such as a printer port. It requires no external controlling software except a simple BASIC statement to say any expression in its vocabulary. For example, executing OUT 127,120 on the TRS-80 (or POKE −16001,120 on the Apple II) will cause the board to say "Please."

The design and features of the Micromouth speech-processor board are discussed in detail here. But, first, a little background on speech-synthesis techniques, in general, and then details of National Semiconductor's Digitalker system, in particular.

Speech-Synthesis Techniques

Three techniques are presently used to synthesize the human voice: formant synthesis, linear-predictive coding, and waveform digitization. They differ primarily in the number of bits per second of data required to construct a word.

Formant synthesis is essentially a modeling of the natural resonances of the human vocal tract. The bands of resonant frequencies defined are called *formants.* In an electronic synthesizer, these frequencies are generated by excitation sources and are then passed through variable-parameter filters.

One form of the formant technique is called *phoneme synthesis.* In this, the spectral parameters are derived from basic sound units that make up words. A phoneme generator, in turn, reproduces these sounds. In such a circuit, each phoneme has been assigned a code, and the synthesizer module (or chip) utters the corresponding phoneme sound for each code it receives. Creation of continuous speech, therefore, is simply a

Photo 2: *Micromouth speech-processor board shown inserted in peripheral slot 1 of an Apple II computer. Execution of a simple BASIC statement can cause any of the stored vocabulary to be uttered. For example, to make it say "This is Digitalker," a POKE −16001,0 statement would be executed. While the rest of the vocabulary has a male voice, this particular expression has a distinctly female voice.*

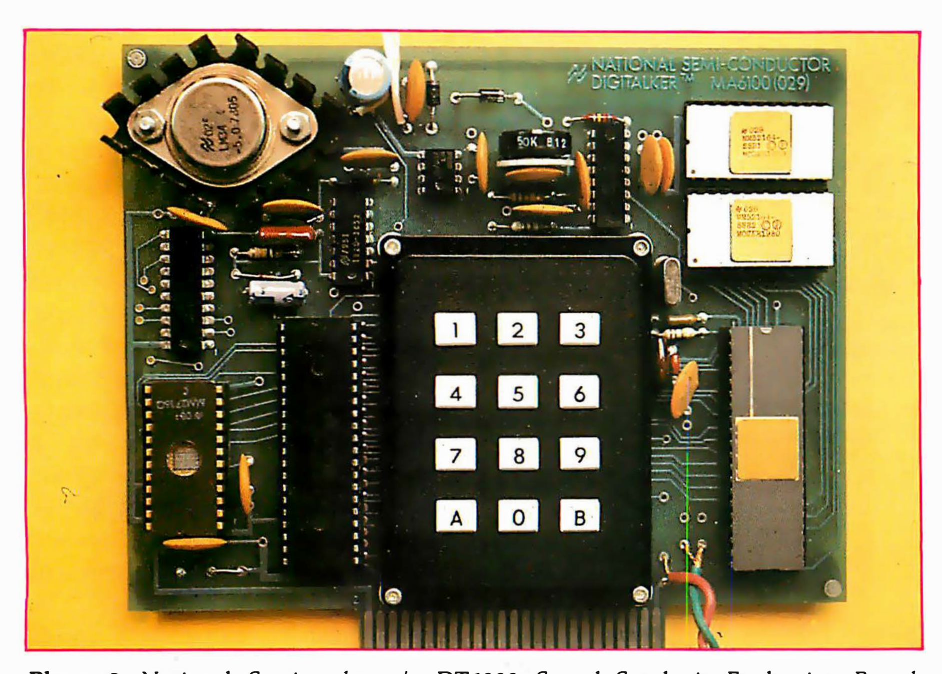


Photo 3: *National Semiconductor's DT1000 Speech-Synthesis Evaluation Board. Available from National Semiconductor distributors for $495, the DT1000 contains a microprocessor equipped with a program that allows a user to hear any single expression or a combination of expressions by entering the appropriate decimal code on the keyboard. While all the I/O lines are available on the Evaluation Board connector and it could be used as a general-purpose speech interface, it is more suitable as a sales tool and demonstration device.*

matter of stringing the phonemes together.

In most cases, the electronic voice generated is quite intelligible, but it may have a mechanical quality about it. Continuous speech using phoneme synthesis can generally be generated with a data rate of less than 400 bps (bits per second). This technique is used by the Votrax Division of Federal Screw Works in the SC-01 Speech Synthesizer Chip and other products.

Linear-predictive coding is similar to formant synthesis. Both techniques are based in the frequency domain and use similar hardware to model

The Digitalker speech processor uses a comprehensive data-compression algorithm.

the vocal tract. Rather than using a simple phoneme code, however, linear-predictive coding stores parameters for filter coefficients, gain, and excitation frequencies. The term "linear-predictive coding" refers to the programmed activities of the multistage lattice filters that produce the desired formants. Adequate-quality speech can generally be achieved with data rates of 1200 to 2400 bps. This synthesis technique is used by Texas Instruments in several products, including the Speak & Spell and the TI 99/4 Text to Speech Translator. It is also used by General Instrument Corporation in its Orator VSM2032 Voice-Synthesis Module.

The third method is *waveform digitization*. This very old technique produces speech by generating a waveform with the time-domain characteristics of voice, in contrast to the previously considered parameter-encoding methods, which represent speech in terms of frequency. The simplest form is uncompressed digital data recording, called PCM, for pulse-code modulation. (In the June 1978 BYTE, my article entitled "Talk to Me: Add a Voice to Your Computer for $35," page 142, discussed how to build a simple digitized speech interface.)

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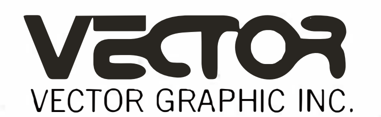
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In simple PCM recording, the analog speech waveform is sampled at a rate twice that of the frequency of the highest voice component and converted to digital format through an A/D (analog-to-digital) converter. Once stored, the digital signal can be played back through a D/A (digital-to-analog) converter and a low-pass filter. One major advantage of digitally encoded speech is its human-like quality. Since it is in essence a recorded voice, the reproduced speech retains the inflections and accents of the original voice. Thus, in addition to male and female voices, it is possible to have a speech synthesizer that reproduces regional or foreign accents. The clarity of the reproduction depends on the speech-compression method used.

Unfortunately, one problem in using PCM alone is that it requires very high data rates. Rates above 100 k bps are not unusual with this method. To reduce the data rate, it is necessary to compress the speech data to remove redundant information. One compression method is called *delta modulation*. As in PCM, the analog speech waveform is sampled, but this time only the *changes* in amplitude (delta values) between samples are stored. Since speech contains many redundant sounds and silences, these changes are much smaller than the absolute amplitude of the waveform, and fewer bits are required to store the smaller values. Delta modulation, therefore, reduces the amount of memory required to store a list of words.

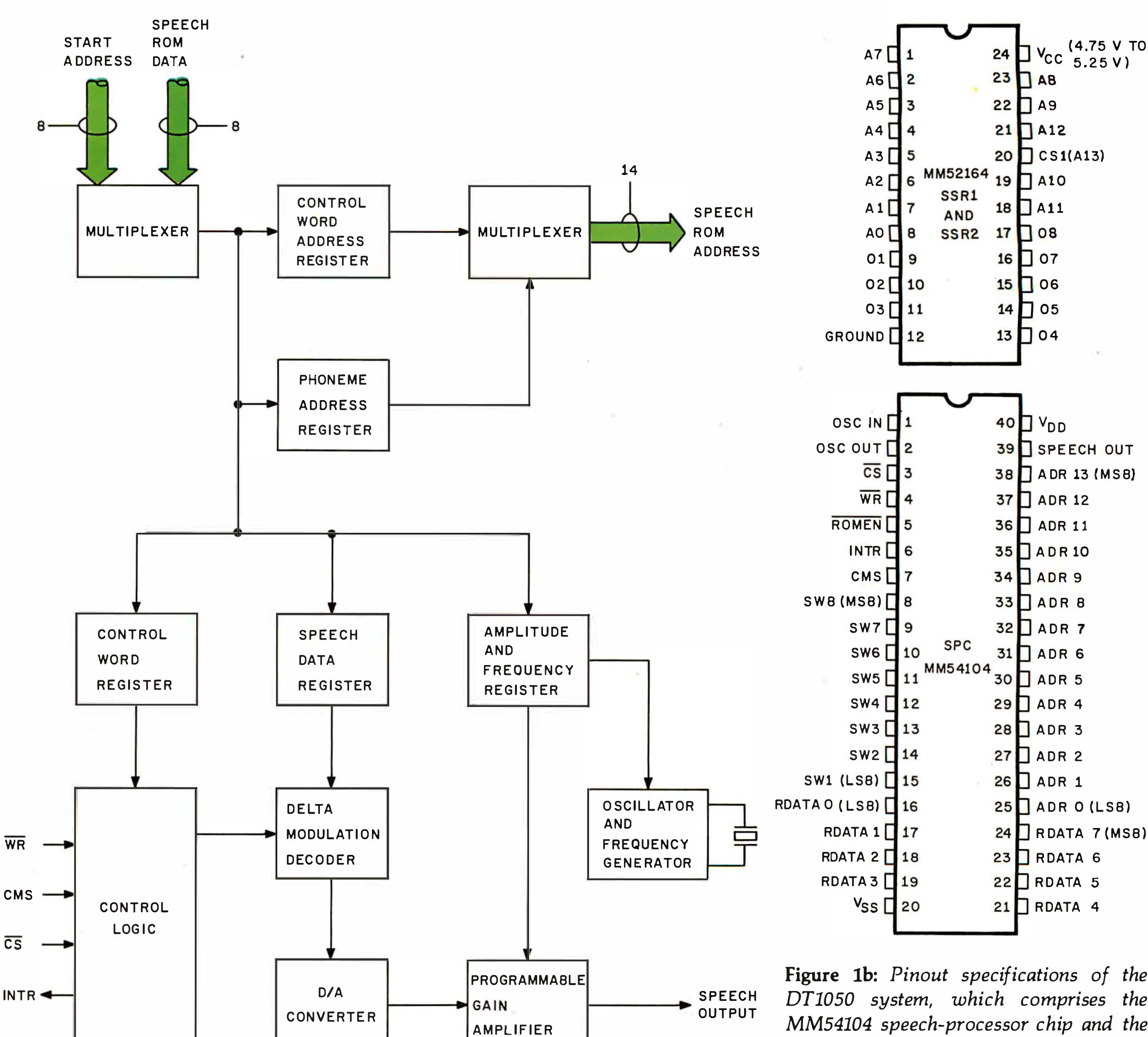


Figure 1a: *Block diagram of the National Semiconductor Digitalker MM54104 speech-processor chip. This figure and figure 2 were provided through the courtesy of National Semiconductor Corporation.*

Figure 1b: *Pinout specifications of the DT1050 system, which comprises the MM54104 speech-processor chip and the associated MM52164 SSR1 and SSR2 ROMs (read-only memories). The ROMs are designed to be used in sets of two; the chip-select (CS1) signals are set up in complementary fashion.*

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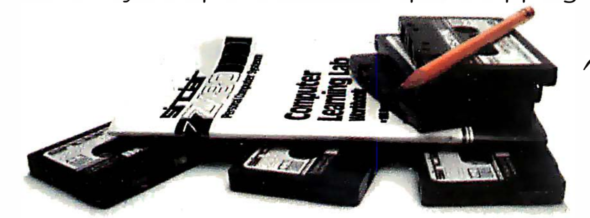
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Ultimately, the total amount of memory required for continuous speech becomes a function of exotic compression algorithms. Data rates as low as 2400 bps have been achieved. The Digitalker speech-synthesis chip set uses data-compressed digitized speech.

Digitalker Components

The Micromouth synthesized-speech-processor board is based upon the National Semiconductor Digitalker DT1050 speech-synthesizer chip set, which consists of a speech processor (SPC) and two 64 K-bit ROMs (read-only memories).

The speech processor uses PCM encoding with a comprehensive data-compression algorithm developed by Forest Mozer at the University of California, Berkeley. The primary compression method employed is delta modulation. As previously described, this concept recognizes that speech waveforms are generally smooth and continuous. Rather than storing the absolute amplitude of the voice signal, the differences between successive samples are stored instead. During speech reconstruction, successive amplitudes in the output waveform are obtained by adding these delta values to the previous values, allowing us to avoid using large numbers of bits to store large voltages.

The speech processor also uses phase-angle adjustment and half-

Word	Decimal Address	Binary Address
This is Digitalker	000	00000000
one	001	00000001
two	002	00000010
three	003	00000011
four	004	00000100
five	005	00000101
six	006	00000110
seven	007	00000111
eight	008	00001000
nine	009	00001001
ten	010	00001010
eleven	011	00001011
twelve	012	00001100
thirteen	013	00001101
fourteen	014	00001110
fifteen	015	00001111
sixteen	016	00010000
seventeen	017	00010001
eighteen	018	00010010
nineteen	019	00010011
twenty	020	00010100
thirty	021	00010101
forty	022	00010110
fifty	023	00010111
sixty	024	00011000
seventy	025	00011001
eighty	026	00011010
ninety	027	00011011
hundred	028	00011100
thousand	029	00011101
million	030	00011110
zero	031	00011111
A	032	00100000
B	033	00100001
C	034	00100010
D	035	00100011
E	036	00100100
F	037	00100101
G	038	00100110
H	039	00100111
I	040	00101000
J	041	00101001
K	042	00101010
L	043	00101011
M	044	00101100
N	045	00101101
O	046	00101110
P	047	00101111
Q	048	00110000
R	049	00110001
S	050	00110010
T	051	00110011
U	052	00110100
V	053	00110101
W	054	00110110
X	055	00110111
Y	056	00111000
Z	057	00111001
again	058	00111010
ampere	059	00111011
and	060	00111100
at	061	00111101
cancel	062	00111110
case	063	00111111
cent	064	01000000
400 Hz tone	065	01000001
80 Hz tone	066	01000010
20 ms silence	067	01000011
40 ms silence	068	01000100
80 ms silence	069	01000101
160 ms silence	070	01000110
320 ms silence	071	01000111
centi	072	01001000
check	073	01001001
comma	074	01001010
control	075	01001011
danger	076	01001100
degree	077	01001101
dollar	078	01001110
down	079	01001111
equal	080	01010000
error	081	01010001
feet	082	01010010
flow	083	01010011
fuel	084	01010100
gallon	085	01010101
go	086	01010110
gram	087	01010111
great	088	01011000
greater	089	01011001
have	090	01011010
high	091	01011011
higher	092	01011100
hour	093	01011101
in	094	01011110
inches	095	01011111
is	096	01100000
it	097	01100001
kilo	098	01100010
left	099	01100011
less	100	01100100
lesser	101	01100101
limit	102	01100110
low	103	01100111
lower	104	01101000
mark	105	01101001
meter	106	01101010
mile	107	01101011
milli	108	01101100
minus	109	01101101
minute	110	01101110
near	111	01101111
number	112	01110000
of	113	01110001
off	114	01110010
on	115	01110011
out	116	01110100
over	117	01110101
parenthesis	118	01110110
percent	119	01110111
please	120	01111000
plus	121	01111001
point	122	01111010
pound	123	01111011
pulses	124	01111100
rate	125	01111101
re	126	01111110
ready	127	01111111
right	128	10000000
ss	129	10000001
second	130	10000010
set	131	10000011
space	132	10000100
speed	133	10000101
star	134	10000110
start	135	10000111
stop	136	10001000
than	137	10001001
the	138	10001010
time	139	10001011
try	140	10001100
up	141	10001101
volt	142	10001110
weight	143	10001111

Table 1: *The 144 spoken expressions in the vocabulary of the standard Digitalker system, with word-access codes in decimal and binary. The "ss" expression is a generalized hissing sound provided to make plurals out of other words in the list. If an address greater than 143 is sent to the speech processor, it "executes data" and nonsense sounds are generated.*

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period zeroing compression techniques. Phase-angle adjustment is based on the concept that the intelligibility of speech is not affected by the phase angle of the sine-wave components of the Fourier-transformed waveforms. Therefore, these values can be adjusted to produce a waveform with mirror symmetry; only half the data need be stored.

In half-period zeroing, the low-amplitude portions of a signal are reproduced as silence. For the most part, only the center half of any pitch period needs to be stored since the center half contains most of the energy. The remainder of the waveform is relatively insignificant and can be discarded.

The 144-expression Digitalker vocabulary was initially recorded through a microphone, then differentiated and digitized. A computer program operated on the data to perform phase-angle adjustment, delta modulation, and half-period zeroing. The redundant pitch periods and phonemes were reduced to individual stored periods and a record of the number of times they are repeated (usually 3 to 8 times). The resulting data containing frequency, amplitude, and control information is stored in the two 64 K-bit speech ROMs.

The Digitalker system introduces low-cost speech output into areas where the expense has not been previously justified.

Figure 1a is a block diagram of the speech-processor chip. Each block of speech data contains a control word specifying the location in ROM of an audible expression, the type of waveform generated, and the number of

Text continued on page 58

Figure 2: *Simplified schematic diagram of a minimum-configuration speech demonstration system, in which mechanical switches are used to set up the desired word. The momentary switch is a single-pole, two-position type. The crystal is a 4.0 MHz Electro Dynamics Corporation HC18 20 pF unit.*

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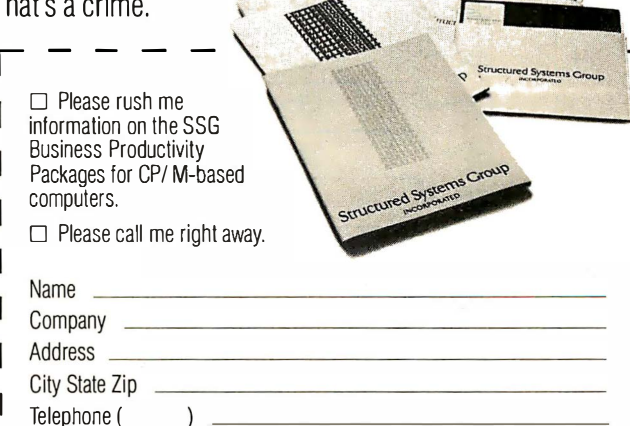
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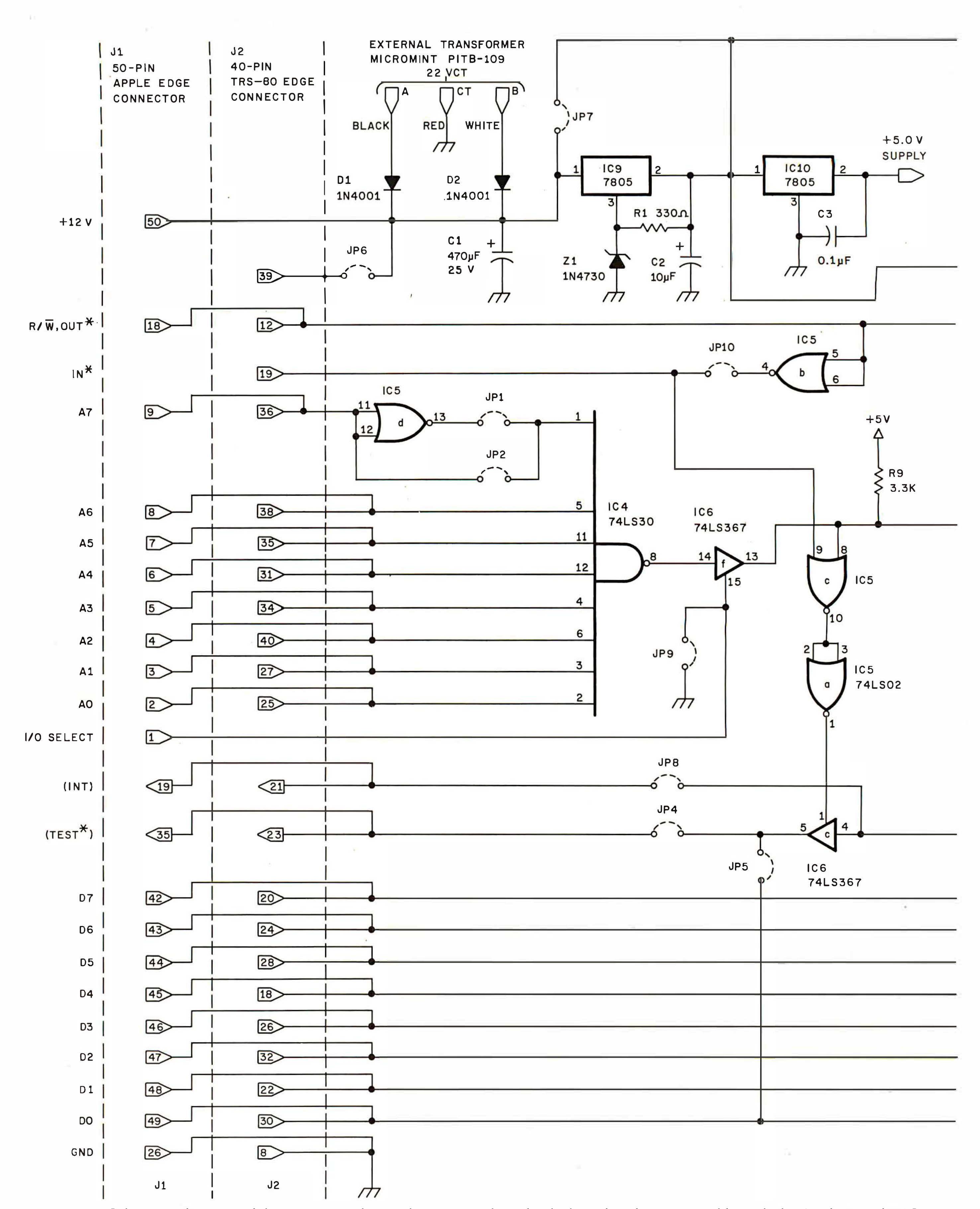
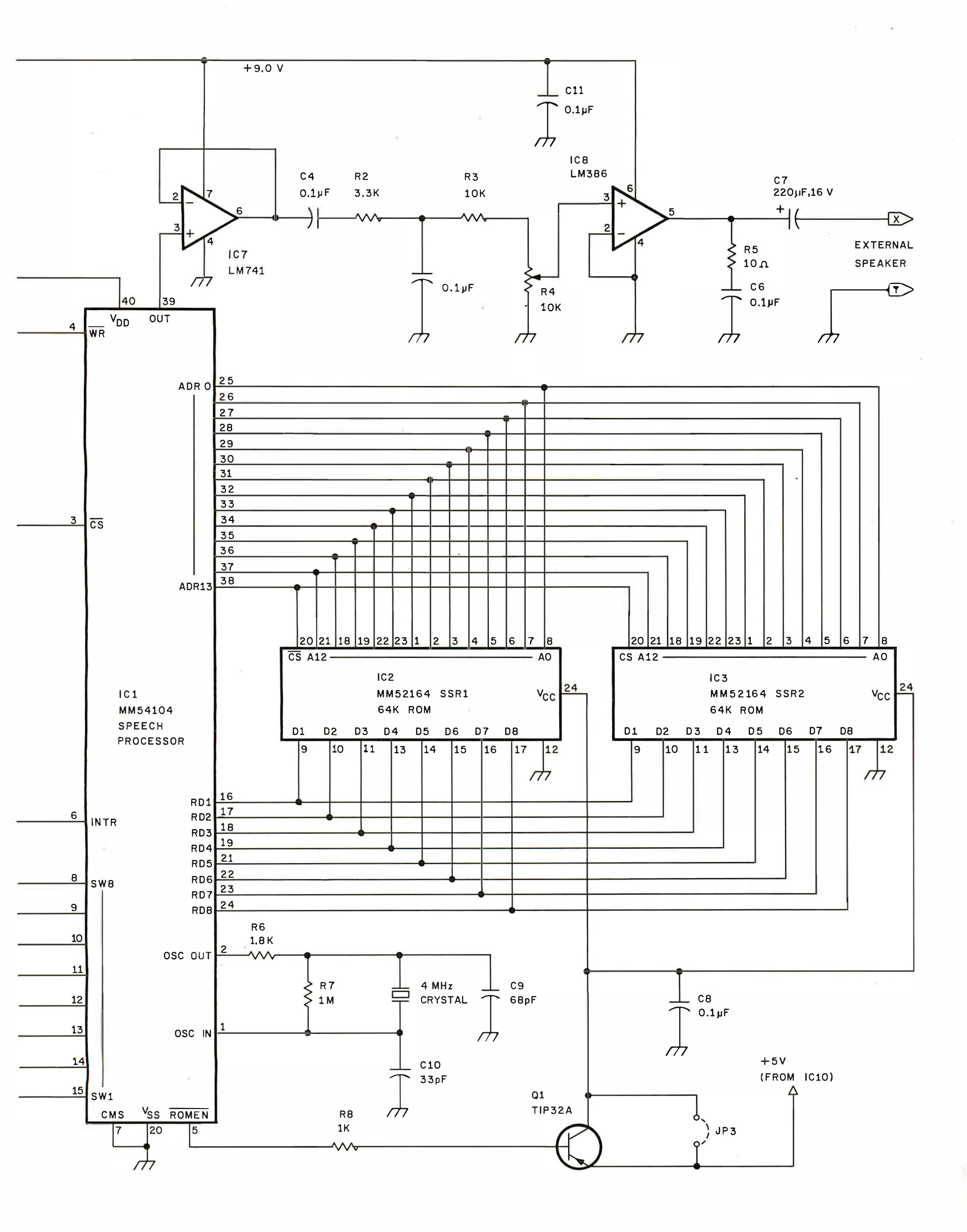


Figure 3: *Schematic diagram of the Micromouth speech-processor board. The board is plug-compatible with the Apple II and TRS-80 Model I computers and can be plugged into the TRS-80 Model III with a simple adapter. Several features and options in the circuit are activated by selection of jumper connections; see table 3, on page 58, for a list of jumpers and their purposes. Interface signals are compatible with other microcomputers, including Digital Group, Heath H-8, and S-100-bus systems.*


+9.0 V
C11
0.1µF
IC8
LM386
C4
0.1µF
R2
3.3K
R3
10K
C7
220µF,16 V
IC7
LM741
0.1µF
R4
10K
R5
10Ω
C6
0.1µF
EXTERNAL
SPEAKER
VDD
OUT
WR
CS
ADR 0
ADR13
IC1
MM54104
SPEECH
PROCESSOR
CS A12
A0
IC2
MM52164 SSR1
64K ROM
VCC
D1 D2 D3 D4 D5 D6 D7 D8
CS A12
A0
IC3
MM52164 SSR2
64K ROM
VCC
D1 D2 D3 D4 D5 D6 D7 D8
INTR
SW8
SW1
RD1
RD2
RD3
RD4
RD5
RD6
RD7
RD8
R6
1.8K
OSC OUT
R7
1M
4 MHz
CRYSTAL
C9
68pF
C8
0.1µF
OSC IN
C10
33pF
+5V
(FROM IC10)
Q1
TIP32A
JP3
R8
1K
CMS
VSS
ROMEN

Text continued from page 54:
times it is repeated. Speech data from the ROM is loaded into the speech processor's data register and passed on to the delta-modulator decoder. This produces a 4-bit number that is applied to the D/A converter. Successive and regressive (remember the mirror waveform) digitizations produce a final waveform that is output in real time. Figure 1b shows the pinout specifications of the speech processor and the associated ROMs.

Adding a Digitalker Interface

In general, causing any of the 144 stored expressions to be uttered is done by loading a numeric word code into a register in the speech processor. The code, selected from the list in table 1, is latched when the write-enable and chip-select lines are strobed. The speech processor immediately utters the selected expression.

If the input code is 0, the message "This is Digitalker" is spoken, in about 1.3 seconds. To say a word like "at" takes much less time. If another word-selection address is strobed into the speech processor while it is speaking, it will terminate the current output and begin speaking the newly selected expression. To keep the unit from jamming one word on top of another, a handshaking signal (INTR) goes to a low logic condition when the device is talking.

The simplest Digitalker system can consist of as little as the three speech-system integrated circuits, a 4 MHz oscillator, and an amplifier/filter (as shown in figure 2). Different expressions can be accessed by attaching eight switches to the SW1 thru SW8 input lines and a pushbutton switch to momentarily pulse the write-enable line.

Full use of the Digitalker's capabilities, however, can only be achieved when it is connected to a computer and exercised under program control. Figure 3, on pages 56 and 57, is the schematic diagram of the Micromouth speech-synthesizer interface, which incorporates the Digitalker chips. It is designed to be bus-signal-compatible with a number of computers, and it can be operated through a parallel I/O port. Assembled on the printed-circuit board shown in photo 1, it is plug-compatible with the Apple II and TRS-80 Model I personal computers. The pin numbers listed in the figure for connector J2 correspond to the TRS-80 Model I TRS-BUS edge connector, and pin numbers listed for J1 correspond to the Apple II's I/O card slots. A source for the Micromouth speech-processor assembled unit, blank boards, and components is given in the text box on page 68.

	Address Jumpers			
	JP1		JP2	
Peripheral Slot	Hexadecimal	Decimal	Hexadecimal	Decimal
1	C17F	−16001	C1FF	−15873
2	C27F	−15745	C2FF	−15617
3	C37F	−15489	C3FF	−15361
4	C47F	−15233	C4FF	−15105
5	C57F	−14977	C5FF	−14849
6	C67F	−14721	C6FF	−14593
7	C77F	−14465	C7FF	−14337

Table 2: *I/O addresses used by the Apple II in communicating with the Micromouth speech-processor board. These are addresses in the Apple's peripheral-card ROM address space. The driving software can manipulate these registers using memory-reference instructions; in BASIC, PEEK and POKE are used.*

Jumper Connection	Purpose
JP1	When connected, sets TRS-80 I/O-port address to decimal 127; mutually exclusive with JP2; see table 2 for Apple II addressing.
JP2	Sets TRS-80 I/O-port address to decimal 255; see table 2 for Apple II addressing.
JP3	To be connected if transistor Q1 is to be omitted and an adequate external power supply is to be used.
JP4	Not for use with either TRS-80 or Apple II computers; provides INTR feedback to computer, gated by the address strobe; see also JP8.
JP5	When connected, enables use of a bidirectional data bus; otherwise a unidirectional bus is assumed.
JP6	Not for use with either TRS-80 or Apple II; when the 40-pin edge connector is used, a +12 V supply may be provided to the board through pin 39.
JP7	May be connected if an external +9 V or +8 V supply is available.
JP8	Not for use with either TRS-80 or Apple II; provides INTR feedback to computer, although not gated as through JP4.
JP9	Must be connected when board is used with a TRS-80; enables I/O commands to be decoded properly.
JP10	Must be connected when board is used with an Apple II; provides proper I/O-command decoding.

Table 3: *List of jumper connections in the schematic diagram of figure 3. Various features and options of the Micromouth speech-processor board are activated by connecting different jumpers. Some options are not needed when the board is used with an Apple II or a TRS-80. Experimenters with other computers may use the 40-pin and 50-pin edge connectors in nonstandard ways; therefore some connections have been provided that have no obvious use.*

Micromouth Versatility

The Micromouth board is designed to accommodate bidirectional as well as unidirectional data buses. The data-bus lines are normally attached to pins 8 thru 15 of IC1, the speech-processor component. The bus line from the speech processor, INTR, is jumpered (by either jumper connection JP4 or JP5) to meet the requirements of the particular bus being used. For both the TRS-80 and Apple II, which have bidirectional data buses, jumper JP5 is inserted to connect the INTR output to the D0 bus

Text continued on page 62

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Circle 16 on inquiry card.

Text continued from page 58:
line. The controlling computer can read the status of this line with an input instruction; only the least-significant bit will be affected. For a unidirectional data bus, as in a Digital Group computer, JP4 would be inserted and pin 5 of IC6 connected to the least-significant bit of the input bus.

The logic gates of IC4, IC5, and IC6 perform address decoding and chip selection. The I/O-port address of the board is set by inserting jumper JP1 or JP2. With JP1 installed, the address is port hexadecimal 7F (decimal 127). With JP2 installed, it is port hexadecimal FF (decimal 255). On the Apple II, the port address depends upon the slot in which the board is inserted. Table 2 is an address map for the Micromouth speech-processor board installed in an Apple II.

The speech-processor chip requires +7 to +11 V for normal operation, while the ROMs and other integrated circuits require only a +5 V supply. To accommodate the different ranges, I used two separate voltage regulators. IC9, a 7805 regulator, can safely be fed an input-voltage range of +9 to +24 V. When installed in an Apple II it receives a +12 V supply from the I/O bus. When the board is used with the TRS-80, a separate full-wave power supply using a 22 V center-tapped power transformer supplies approximately +15 V RMS. IC9 and associated components regulate the output to the speech processor to about +9 V. IC10, another 7805, in turn, reduces the +9 V to the +5 V required by the rest of the components.

The typical maximum current requirement of the Micromouth speech-processor circuitry is about 250 mA. Most of this is consumed running the two 64 K-bit ROMs, which are used only a few microseconds at a time. A memory-enable signal, $\overline{ROMEN}$, can be used with a transistor (Q1) to gate the power on and off to the ROMs. The average current required ends up being about 80 mA.

The final section for consideration is the filter and amplifier, IC7 and IC8. As in any digitized analog-signal output, a low-pass filter is required. For low-pitched male voices, the cutoff frequency should be about 100 Hz; for high-pitched female or children's voices it should be 300 Hz. The filter in figure 3 has a cutoff frequency around 150 Hz. That limit wasn't set mathematically; I simply chose a pleasant-sounding range. The frequency response of the output speaker and its enclosure can also affect sound quality. In my opinion, the sound output by this circuit is quite human-like. Any additional filtering usually serves only to eliminate background noise.

Using a Parallel Port

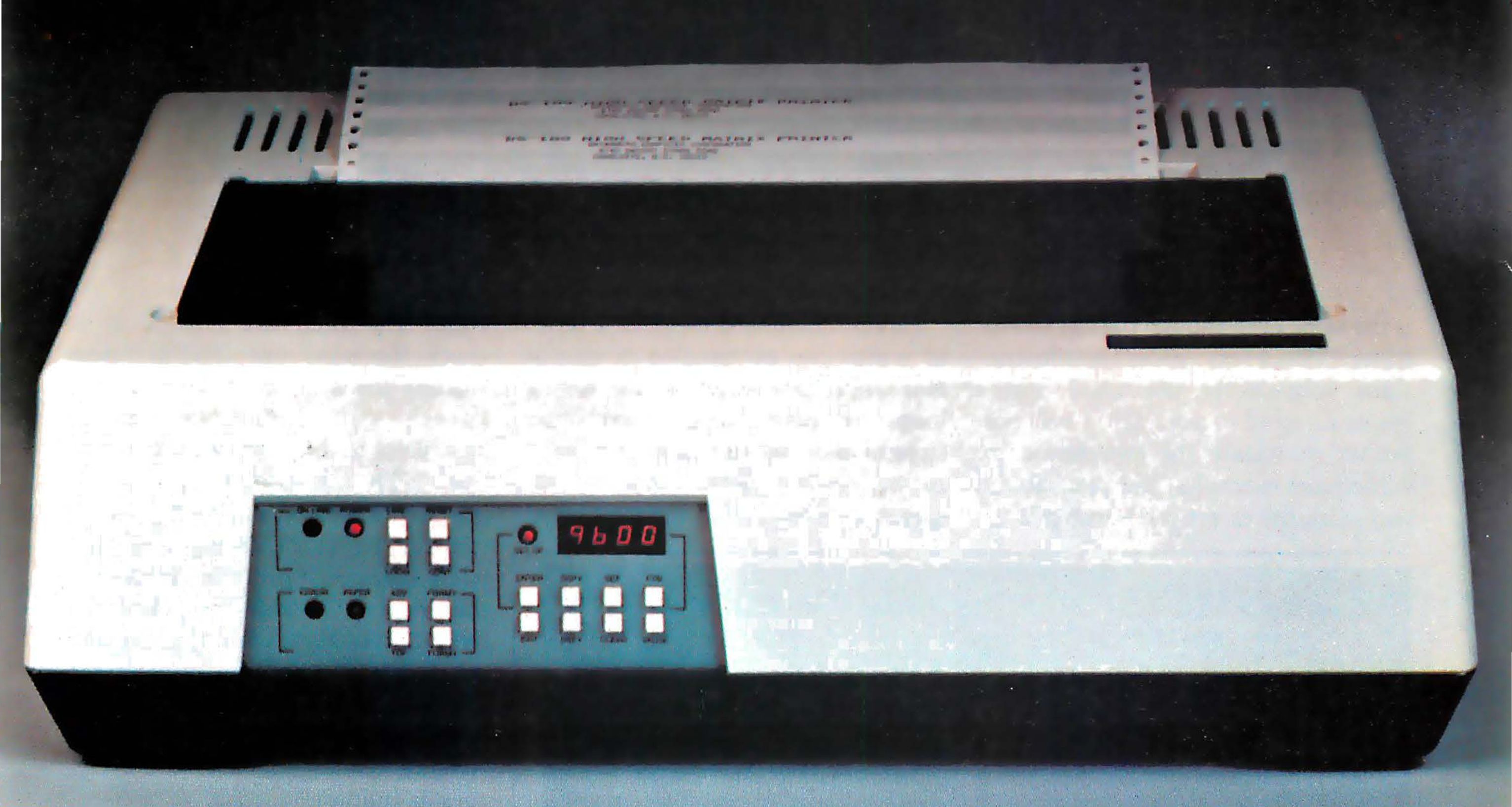
The Micromouth board can also be jumpered so that it can be driven by a parallel I/O port. This is accomplished by inserting jumpers JP8 and JP9. With the input lines to IC5 and IC6 left open, a constant chip-select signal will be generated. The 8-bit parallel output from the computer is attached to pins 8 thru 15 on the speech processor. The same signal that latches the bit values into the output port can be used as the $\overline{WR}$ strobe on IC1 pin 4. The speech-processor-busy status indication is handled by directly reading the INTR line via an input-port line.

Basic Software Simplicity

The best thing about a fixed vocabulary "canned-speech" synthesizer is the low software overhead. Text-to-speech synthesizers, on the other hand, usually require at least an 8 K-byte driver program, which must be integrated into the existing operating system. With the Micromouth speech-processor board, any or all of the 144 expressions can be spoken using a simple BASIC OUT or POKE statement.

For example, to say "twenty" using the board connected to a TRS-80 system, you would execute an OUT 127,20 statement in BASIC. With the Apple II, the appropriate statement would be POKE −16001,20 if the board were installed in slot 1. As you can see, the control information communicated to the board, a decimal 20,

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Listing 1: *A BASIC program for the Radio Shack TRS-80 Model I that will cause the Micromouth speech-processor board to say "At the mark the time is 2:45 pm....beep." A program for the Apple II would use the POKE keyword to achieve the same effect as the OUT statement.*

```
100  DIM N(15)
110  DATA 61,138,105,71,138,139,
     96,2,4,5,47,44,71,71,65
120  FOR X=1 TO 15 :READ N(X)
     : NEXT X

150  FOR X=1 TO 15 : OUT 127,N(X)
     : GOSUB 1000 : NEXT X
160  GOTO 1999

1000 IF INP(127)=1 THEN
     GOTO 1000 ELSE RETURN
1999 END
```

Listing 2: *A BASIC program that will cause the Micromouth speech-processor board to recite multiplication results for any number between 1 and 10.*

```
100 PRINT "MULTIPLICATION TABLE EXERCISER"
110 OUT 127,0:REM Say This is Digi-Talker
120 PRINT:PRINT"Which table do you want to review (1 to 10)";
130 INPUT N
140 FOR X=0 TO 10
150 PRINT X;"X";N;"=";X*N:J=X*N
160 IF X=0 THEN OUT 127,31:GOSUB 290:GOTO 180
170 OUT 127,X:GOSUB 290
180 GOSUB 310:OUT 127,N:GOSUB 290
190 OUT 127,80:GOSUB 290:OUT 127,129:GOSUB 290
200 J1=INT(J/10)
210 IF J=100 THEN OUT 127,1:GOSUB 290:OUT 127,28:GOSUB 290:GOTO 260
220 IF J=0 THEN OUT 127,31:GOSUB 290:GOTO 260
230 IF J<20 THEN OUT 127,J:GOSUB 290:GOTO 260
240 OUT 127,18+J1:GOSUB 290
250 IF J-J1*10>0 THEN OUT 127,J-J1*10:GOSUB 290:GOTO 260
260 NEXT X
270 PRINT:GOTO 120
280 REM
290 IF INP(127)=1 THEN 290 ELSE RETURN:REM check end of word
300 REM
310 OUT 127,139:GOSUB 290:OUT 127,129:GOSUB 290:RETURN
320 REM say TIMES

READY
```

is the same even though the keywords differ. (Since my program illustrations consistently use OUT statements directed to port 127, I will not bother to restate the conversion in subsequent examples, but you should recognize the direct relationship.)

Having the board speak in a series of words can be handled in one of two ways. One way is to use timing loops or other program-execution steps to allow enough time for a word to be spoken before loading the speech processor with the next word code. The preferred method is to check the busy line (INTR) before loading the next word. In this way, speech can sound continuous regardless of the length of each word. The INTR status bit is read as the least-significant bit of port 127 by the function INP(127). In my examples, while the speech processor is talking, the decimal value returned by INP(127) equals 1; while it is not talking, INP(127) equals 0.

Therefore, saying the number twenty-one, which consists of saying "twenty" and "one" successively, goes as follows:

```
100  OUT 127,20 : GOSUB 1000
     : OUT 127,1
110  STOP
1000 IF INP(127)=1 THEN
     GOTO 1000 ELSE RETURN
1999 END
```

A similar program can be used to demonstrate the entire Digitalker vocabulary:

```
100  FOR N=0 TO 143 : OUT
     127,N : GOSUB 1000
     : NEXT N
110  STOP
1000 IF INP(127)=1 THEN
     GOTO 1000 ELSE RETURN
1999 END
```

Longer utterances are typically

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Listing 3: *A BASIC program to demonstrate several different ways of using the speech interface.*

```
50 DIM N(20),M(60)
55 DATA 71,138,139,96,71,12,69,93,129,71
60 DATA 17,69,110,129,71,71,71,71,71,71,71
65 FOR T=1 TO 19: READ N(T):NEXT T
70 DATA 65,71,76,71,71,75,81,71,71,105,71,7,20,47,44,71,71
75 DATA 83,125,96,1,28,21,6,85,129,32,110,71,71,104,133
80 DATA 2,12,28,049,047,044,60,131,83,125,2,1,28,10,85
85 DATA 129,32,110, 71,71,71,71,71
90 FOR T=1 TO 56:READ M(T):NEXT T
100 REM DIGI-TALKER TEST PROGRAM
110 PRINT "DIGI-TALKER TEST PROGRAM"
120 PRINT: PRINT"1. Say entire vocabulary"
130 PRINT"2. Count from 0 to 20"
140 PRINT"3. Tones"
150 PRINT"4. Speech example A"
160 PRINT"5. Speech example B"
165 PRINT"6. Say 'THIS IS DIGI-TALKER'"
170 PRINT:PRINT"Enter choice (1-5) ";:INPUT A
180 IF A=1 THEN GOSUB 250
190 IF A=2 THEN GOSUB 300
200 IF A=3 THEN GOSUB 350
210 IF A=4 THEN GOSUB 400
220 IF A=5 THEN GOSUB 450
225 IF A=6 THEN OUT 127,0:GOSUB 1000
230 GOTO 110
250 REM speak entire word list
260 FOR T=0 TO 143:OUT 127,T:GOSUB 1000
270 NEXT T: RETURN
300 REM speak numbers 0-20
310 OUT 127,31: GOSUB 1000
320 FOR T=1 TO 20: OUT 127,T: GOSUB 1000
330 NEXT T: RETURN
350 REM 80 Hz and 400 Hz tone
360 FOR T=0 TO 5:OUT 127,65:GOSUB 1000
370 OUT 127,66:GOSUB 1000:NEXT T
380 RETURN
400 REM Speak Time
410 FOR B=0 TO 5:OUT 127,65:GOSUB 1000
415 FOR C=0 TO 2:OUT 127,71:GOSUB 1000:NEXT C
420 NEXT B
425 FOR T=1 TO 18 :OUT 127,N(T):GOSUB 1000:NEXT T
430 FOR T=0 TO 5:OUT 127,65:FOR S=0 TO 100:NEXT S:NEXT T
440 RETURN
450 REM example of use as error detector and verbal annunciator
460 FOR T=1 TO 55: OUT 127,M(T):GOSUB 1000:NEXT T
470 RETURN
1000 IF INP(127)=1 THEN 1000 ELSE RETURN
1010 IF INP(127)=1 THEN 1010 ELSE RETURN

READY
```

Listing 4: *The printed output of the program in listing 3. Due to the limitations of magazine printing, we cannot reproduce the audible output produced by the program.*

```
run
DIGI-TALKER TEST PROGRAM

1. Say entire vocabulary
2. Count from 0 to 20
3. Tones
4. Speech example A
5. Speech example B
6. Say 'THIS IS DIGI-TALKER'

Enter choice (1-5) ?
```

handled by storing all the word codes in an array. Such a technique can be used to say, "At the mark the time is 2:45 pm....*beep*," using the BASIC statements in listing 1.

I have included a few program examples to demonstrate how the speech-processor board can be used. Listing 2 is a simple program for saying multiplication tables. This program asks the operator to choose a multiplication table for a number between 1 and 10. If 8 were chosen, for example, the program would say:

"Zero times eight equals zero."
"One times eight equals eight."
"Two times eight equals sixteen."

and so on to:

"Ten times eight equals eighty."

This is just a rudimentary example. The program could be modified easily to posit questions such as "Six times nine equals..." and wait for a typed response. Appropriate answers would be "Error...Please try again," or "Right."

Listing 3, on page 66, is a menu-driven program that further exercises the interface and demonstrates a few more applications. Speech example A says, *"beep... beep... beep... beep...* The time is...twelve hours...seventeen minutes...*beep*." It is very much like the time message heard over shortwave radio station CHU Canada.

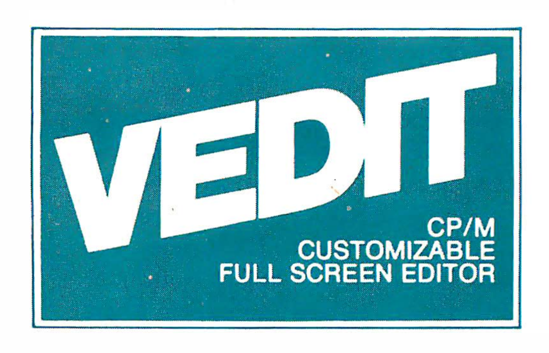
Speech example B from listing 3 illustrates how process-control applications might be handled. It says, "Control error...Mark seven twenty pm...Flow rate is thirty gallons a minute...Lower speed to twelve hundred rpm and set flow rate to one hundred gallons a minute."

In Conclusion

Applications that would be enhanced by speech output are limitless. I have demonstrated just a few examples dealing with process control and time.

Many handicapped persons could benefit from speech output. It would be possible, for example, to attach a speech-output device to the user-terminal keyboard of a personal computer. As the keys are pressed, the corresponding letters are spoken aloud. (A simple ROM containing Digitalker equivalents for ASCII [American Standard Code for Information Interchange] characters could be used to interface the speech-processor board.) A similar connection can be made to the printer output (using the INTR-signal handshaking to slow it down) to allow the operator to hear what would otherwise be printed.

I did not attempt to modify any computer games as illustrations. Computer games could easily be made to talk using a few extra BASIC



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statements that are independent of the program flow.

What I'd like to leave you with is an appreciation for the price/performance advantages and ease of use inherent in this speech interface. Soon other Digitalker ROMs will be available, containing specialized vocabularies for medical, aeronautical, or even space-war applications. These other ROMs will be available eventually thru the MicroMint.

[**Editor's Note:** *National Semiconductor Corporation is providing a brief telephone demonstration of the Digitalker speech-synthesis system at (408) 737-3939....***RSS**]

The invention of Digitalker does not mean the demise of other approaches to computer-generated speech. Instead, it introduces low-cost speech output into areas that could never have justified the expense previously. Eventually, hand-held talking digital volt-ohmmeters will be mass-produced, and I don't think it will be too far into the future. But that is merely one application. You can expect to see (or rather hear) speech emanating from many commercial products.

Those who work with other speech-synthesis techniques have not been standing still during the development of "canned-speech" chips. Phoneme synthesizers, such as the Votrax SC-01, now accomplish on a single chip what once required a whole circuit board. My investigation of speech synthesis doesn't stop here. In the months ahead I hope to demonstrate other computer-speech techniques, interfaces, and applications.

Next Month:

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The Apple II version of the Micromouth speech-processor board is suitable for use with parallel-I/O-port and other non-plug-compatible computer connections. The assembly/operation instructions include directions for attaching the board to S-100 bus, Digital Group, and Heath H-8 computers.

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The Digitalker integrated circuits are not sold separately by The MicroMint. They can be obtained through National Semiconductor distributors for $85 per set plus shipping charges.

New York residents please add 7% sales tax.

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Editor's Note: *Steve often refers to previous Circuit Cellar articles as reference material for the articles he presents each month. These articles are available in reprint books from BYTE Books, 70 Main St, Peterborough NH 03458.* Ciarcia's Circuit Cellar *covers articles that appeared in BYTE from September 1977 thru November 1978.* Ciarcia's Circuit Cellar, Volume II *presents articles from December 1978 thru June 1980.*

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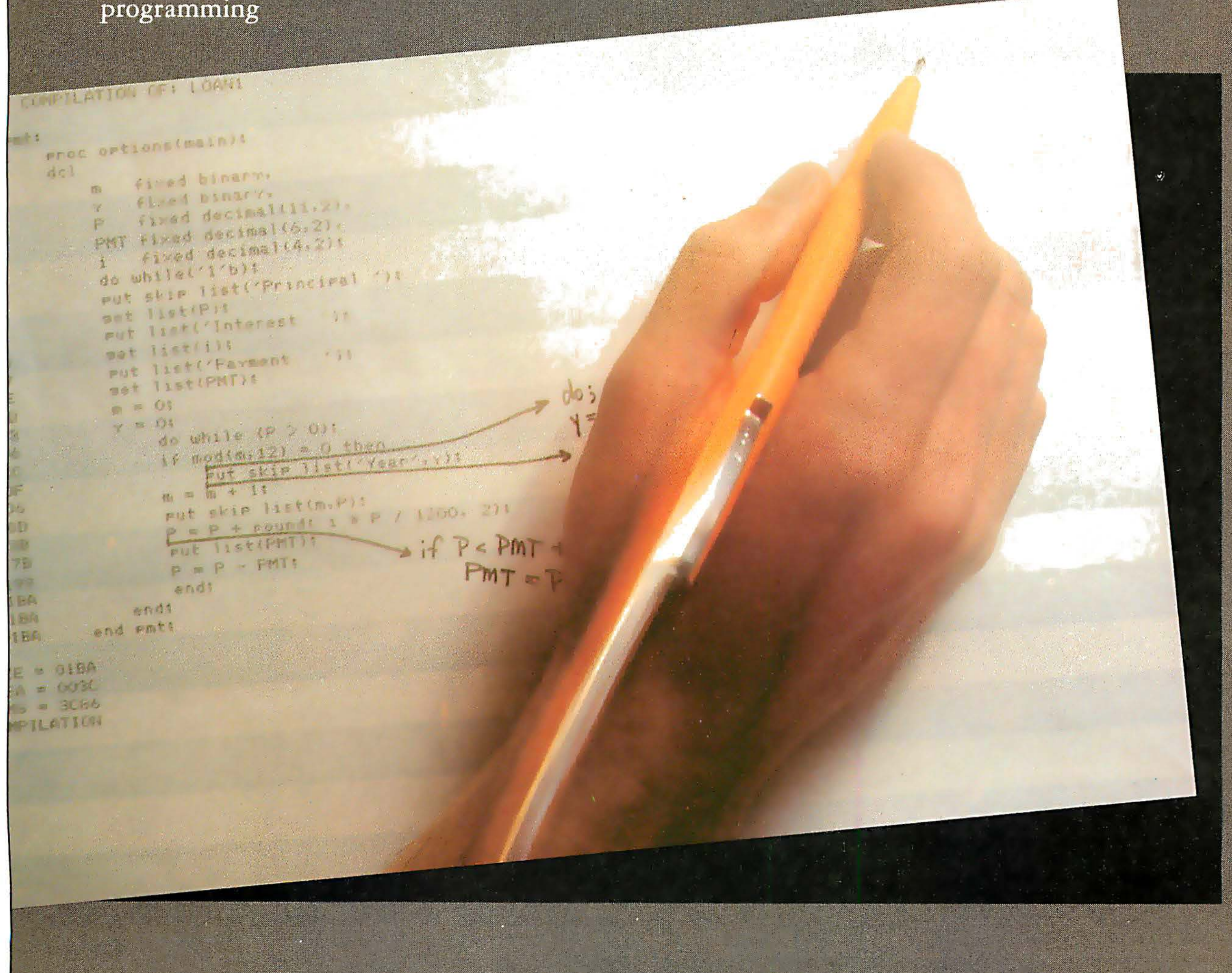
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Mathematical Modeling:

A BASIC Program to Simulate Real-World Systems

Randall E Hicks
University of Georgia
Marine Institute
Sapelo Island GA 31327

Editor's Note: *The subject of this article, simulating systems by solving a system of differential equations, is difficult, but we feel it is useful to many BYTE readers. In fact, only a rudimentary understanding of the principles involved is needed to use the general-purpose BASIC program of listing 2. The involved mathematics at the end of the article presents the theory on which the program is based. . . .* GW

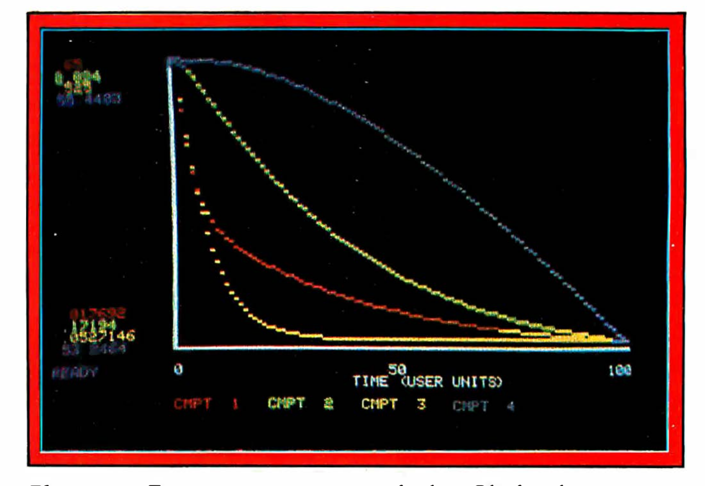


Photo 1: *Zero-input response of the Okefenokee swamp hydrologic model simulated with the program in listing 2.*

Many academic disciplines have used computers for modeling biological, physical, economic, and social systems. Modeling complicated systems once was time-consuming, expensive, and cumbersome. Yet, as computer-related technology advanced, the magnitude of these problems has dwindled, and the potential for less-expensive modeling and simulation tasks in all disciplines has increased.

My purpose is to demonstrate how useful microcomputers can be in mathematical simulations. I will introduce you to modeling the behavior of a system by describing it mathematically with a system of time-invariant linear differential equations. I will show how to solve systems of differential equations by two separate numerical methods. As a framework for the simulation tasks, I will use a simple model as an example for you to follow: a hydrologic model of the forested uplands surrounding Okefenokee swamp in Georiga. (See reference 3.)

The Conceptual Model

To simulate a system, you must be able to conceptualize it into some logical framework. A flow diagram consisting of compartments and connecting flows satisfies this requirement. (See figure 1.) Each compartment in the diagram represents a place for the potential accumulation of energy, matter, or information. A *system* is defined as the collection of compartments that have been outlined and the potential interactions among them. The flows between compartments describe how the system interacts with itself through transfers of the compartmental contents.

The boundaries of the system must also be defined. The *environment* of the system is the area outside the system's periphery. If the system does not interact with its environment, it is called a *closed system*, and the model will not receive inputs from or yield losses to its surroundings. In other words, the system is self-contained. In the Okefenokee swamp uplands hydrologic model, the system is said to be *open* because it interacts with its environment. In the conceptual model (figure 1), this is visualized by an input from the environment to the system and by an output from the system to the environment.

The input to the system (**Z**) is the sum of the flows to each compartment (f_{i0}) from all environmental inputs. The environment surrounding the system is represented by the numeral 0. In the hydrologic model, there is only

About the Author

Randall E Hicks is a graduate student at the University of Georgia working toward his PhD in Ecology at the Institute of Ecology. He is employed by Ecology Simulations Inc, Athens, Georgia, as a marine systems modeling consultant.

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INPUT TO SYSTEM (PRECIPITATION)

$Z = \sum_{i=1}^{4} f_{i0}$

f_{10} f_{20} f_{30}

1 VEGETATION MOISTURE

2 SOIL MOISTURE

3 GROUNDWATER

4 STREAM MOISTURE

f_{21} f_{12} f_{42} f_{34} f_{43}

SYSTEM

f_{01} f_{02} f_{03} f_{04}

ENVIRONMENT

$Y = \sum_{i=1}^{4} f_{0i}$

OUTPUT FROM SYSTEM

Figure 1: *A conceptual model of the hydrology of the forested uplands surrounding Georgia's Okefenokee swamp. The model is subdivided into a* system *and its* environment. *The system receives environmental inputs* (**Z**) *and yields losses* (**Y**) *to the environment. Compartments represent areas of potential water accumulation. Flows and their direction are indicated by connecting arrows. Flows within the system are also given numerical designations. The first number represents the recipient-compartment number and the second represents the donor-compartment number.*

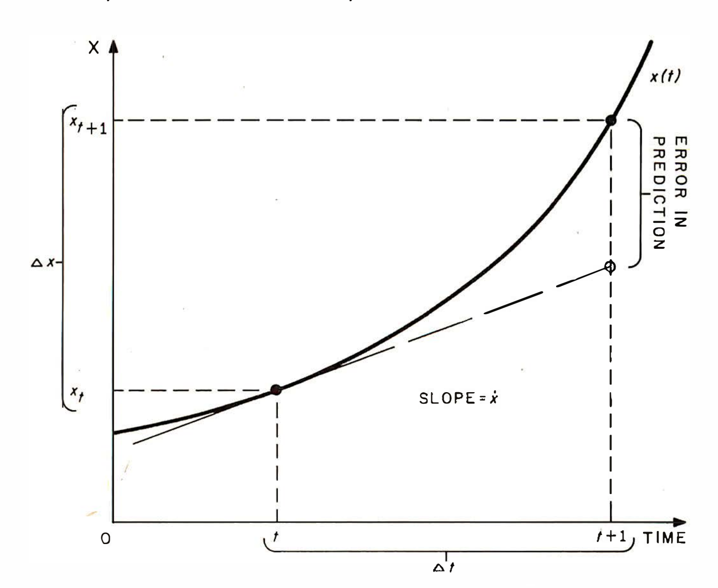


Figure 2: *Geometric interpretation of Euler's method for solving differential equations. Compartment size (x) is plotted versus time (t). Actual and predicted compartment sizes are shown.*

one environmental input to the system: precipitation. Hence:

$$\mathbf{Z} = f_{10} + f_{20} + f_{30} = z_1$$

where the numerical designation of z_k represents an input from environmental input k to the system. Flows within the system are represented by lines connecting compartments; arrows show the direction of flow. These flows are classified by two numbers. The first number indicates the compartment that receives the flow, and the second represents the compartment that yields (ie: produces) the flow. In figure 1, f_{21} designates an actual flow of moisture from vegetation moisture (compartment 1) to soil moisture (compartment 2). The output from the system (**Y**) back to the environment is the sum of the losses from each compartment i (f_{0i}). The purpose of the model is to be able to describe the response of each compartment (ie: how much water is present) at all times in the future.

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The Mathematical Model

The flows into and out of each compartment can be represented by a difference, or a differential, equation. In the model, the flows have been balanced so that no compartment will have a net gain or loss of moisture. The system is said to be at *steady-state*, and the corresponding model will be *static* in nature. The relationships in the flow diagram can be depicted by a system of linear differential equations. In the steady-state example, each differential equation representing a compartment is equal to 0, since inflows and outflows are equal.

For compartment 1 (vegetation moisture), the differential equation would be of the form:

$$\frac{dx_1}{dt} = \dot{x}_1 = f_{10} + f_{12} - f_{21} - f_{01}$$

(**Note**: In this equation, I have used a dot centered over a variable to simplify notation. Henceforth, this will mean the derivative of a variable with respect to time.)

The actual flows (f_{ij}) can be divided by the steady-state size of the corresponding donor compartment (x_j), or by the environment input (z_k), to give two types of coefficients: intercompartmental rate coefficients and environmental input coefficients:

$$a_{ij} = \frac{f_{ij}}{x_j}$$

and:

$$b_{ik} = \frac{f_{i0}}{z_k}$$

where:

i = the recipient compartment
j = the donor compartment

and:

k = an environmental input number

Notice that the intercompartmental coefficients a_{ij} (of matrix **A**) have the same numerical designation as their corresponding flows. Also notice that the environment is represented by a 0 in flows. When environmental input coefficients are formed, you subdivide the total environmental input **Z** into the different types (k) of environmental inputs. These coefficients (b_{ik} of matrix **B**) are dimensionless and express the percentage of an environmental input (z_k of vector **Z**) that each compartment receives. These numerical notations define the position of each coefficient in an appropriate coefficient matrix. For compartment 1 (vegetation moisture), the differential equation then becomes:

$$\dot{x}_1 = a_{12}x_2 - a_{11}x_1 + b_{11}z_{11}$$

After redefining all the differential equations into coefficients multiplied by the appropriate donor-compartment size or environmental-input size, you can organize the system of equations into a single matrix equation:

$$\dot{\mathbf{X}}_{n1} = \mathbf{A}_{nn}\mathbf{X}_{n1} + \mathbf{B}_{nm}\mathbf{Z}_{m1}$$

where:

n = the number of compartments
m = the number of environmental inputs to the system
$\dot{\mathbf{X}}_{n1}$ = a column vector of differential equations

$$\begin{bmatrix} \dot{x}_1 \\ \cdot \\ \cdot \\ \cdot \\ \dot{x}_n \end{bmatrix}$$

$\mathbf{A}_{nn}$ = an n by n matrix of intercompartmental rate coefficients

$$\begin{bmatrix} a_{11} & \cdot & \cdot & \cdot & a_{1n} \\ \cdot & \cdot & & & \cdot \\ \cdot & & \cdot & & \cdot \\ \cdot & & & \cdot & \cdot \\ a_{n1} & \cdot & \cdot & \cdot & a_{nn} \end{bmatrix}$$

$\mathbf{X}_{n1}$ = a column vector of initial compartment sizes

$$\begin{bmatrix} \dot{x}_1 \\ \cdot \\ \cdot \\ \cdot \\ \dot{x}_n \end{bmatrix}$$

$\mathbf{B}_{nm}$ = an n by m matrix of input rate coefficients

$$\begin{bmatrix} b_{11} & \cdot & \cdot & \cdot & b_{1m} \\ \cdot & \cdot & & & \cdot \\ \cdot & & \cdot & & \cdot \\ \cdot & & & \cdot & \cdot \\ b_{n1} & \cdot & \cdot & \cdot & b_{nm} \end{bmatrix}$$

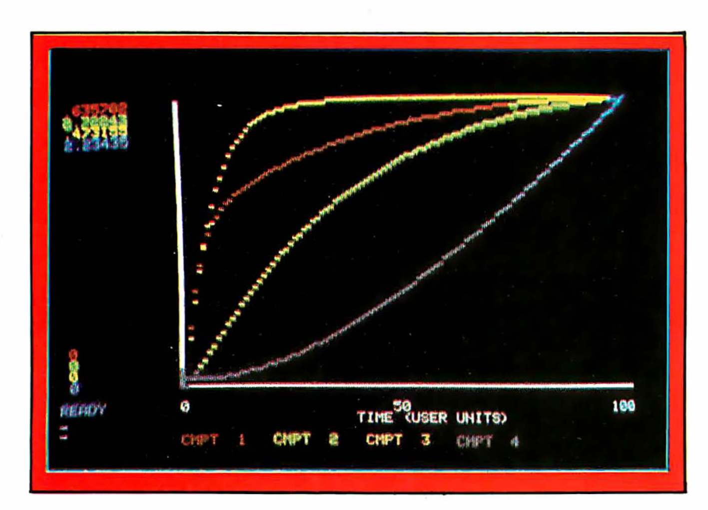
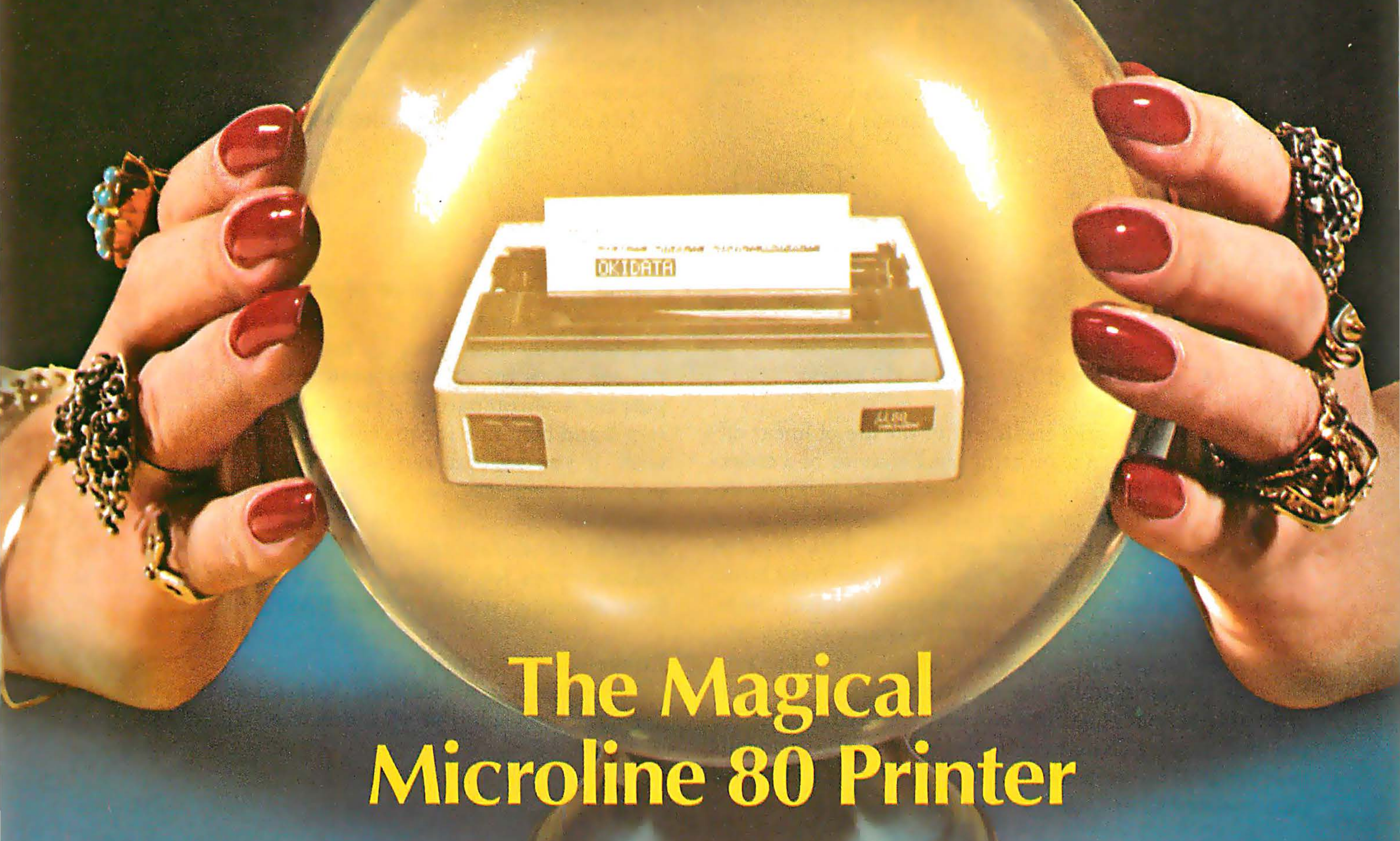


Photo 2: *Zero-state response of the Okefenokee swamp hydrologic model simulated with the program in listing 2.*

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and:

$\mathbf{Z}_{m1}$ = a column vector of environmental input sizes

$$\begin{bmatrix} z_1 \\ \cdot \\ \cdot \\ \cdot \\ z_m \end{bmatrix}$$

The matrices and vectors for the hydrologic model are:

$$\mathbf{A} = \begin{bmatrix} -.369 & .035 & 0.0 & 0.0 \\ .189 & -.0483 & 0.0 & 0.0 \\ 0.0 & 0.0 & -.1632 & .000161 \\ 0.0 & .012 & .000444 & -.000623 \end{bmatrix} \times 1/(10 \text{ years})$$

$$\mathbf{X} = \begin{bmatrix} 0.6500 \\ 2.8940 \\ 0.5250 \\ 55.4400 \end{bmatrix} \times 10^8 \text{m}^3 \text{ water} \qquad \mathbf{B} = \begin{bmatrix} 0.60 \\ 0.07 \\ 0.33 \\ 0.00 \end{bmatrix}$$

and:

$$\mathbf{Z} = [.233] \times 10^8 \text{m}^3 \text{ water} / (10 \text{ years})$$

At best, this is a brief treatment of the use of linear differential equations in simulating the behavior of a collection of components. The hydrologic model herein is described by a deterministic general linear model (GLM) of donor-controlled differential equations. This type of model is among the simplest and the most straightforward to use; it has found wide acceptance in many fields. There are many books on general-systems theory and modeling that go into more detail than I can in this article. (For further reading, see references 4 and 5.) Higher-order differential equations can also be used to describe the time-varying changes in flows between compartments in a model. (See reference 2.) A nonlinear model would incorporate higher-order differential equations.

Numerical Solution of Differential Equations

Now that the model has been described with a system of linear differential equations, a method to solve these equations on a computer is needed. Several numerical methods are available for solving differential equations, but I will discuss only two methods and their implementation on microcomputers: the *Euler* and *Runge-Kutta* methods. I will briefly describe each method and list a corresponding algorithm written in BASIC (Disk BASIC 8001, for the Compucolor II microcomputer) for implementation on a microcomputer. For a more detailed description of these and other methods for solving differential equations, consult a book on numerical analysis or modeling. (See references 1 and 5.)

Euler's (Rectangular) Method

Euler's method is a simple but computationally inefficient method for solving finite differential equations. First, let's look at a geometric interpretation of this method. (See figure 2.)

Knowing the present value (state) of a compartment (x_t), you want to be able to predict the next value (x_{t+1}). Your differential equation for the compartment defines the slope of the line at time t. You project this slope to the next point in time ($t+1$), and add the change in x's value (called Δx) to the value of x at time t (x_t). In many cases (such as in figure 2), the slope of the actual path of the compartment size may not be equal to the predicted value. In these instances, this algorithm has incorporated some error into the predicted value for the compartment size at the new time. In the Euler method, this error is proportional to the time step (Δt). This error can be reduced by decreasing the time step; however, that will increase the algorithm execution time on the computer.

The algorithm for the Euler method is:

1. $\dot{\mathbf{X}}_t = f(\mathbf{X}_t, \mathbf{Z}_t, t)$

2. $\mathbf{X}_{t+1} = \mathbf{X}_t + \Delta t(\dot{\mathbf{X}}_t)$

First, compute the slope of the line at t, which you assume is the same at $t + 1$. In the hydrologic model, this is already determined by the time-invariant differential equations for each compartment. Second, you compute the new compartment size (x_{t+1}). Then you return to step 1 and continue the process for as many times as you wish. If you want to reduce the error in the algorithm, you can decrease your time step and perform the algorithm several times. In this way, you increase the number of iterations of the algorithm before you calculate your final value. Listing 1 is a program for the Euler algorithm written in Disk BASIC 8001.

Runge-Kutta Method

Runge-Kutta is a multistep, look-forward method for the numerical solution of differential equations. I will

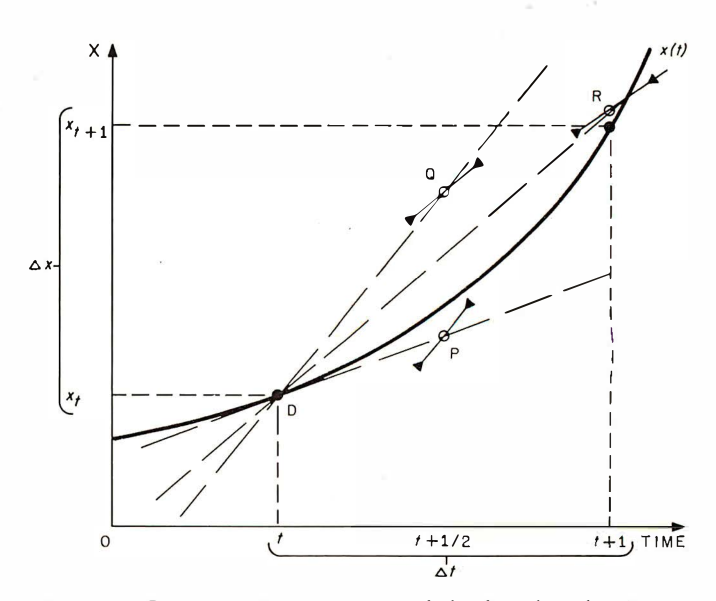
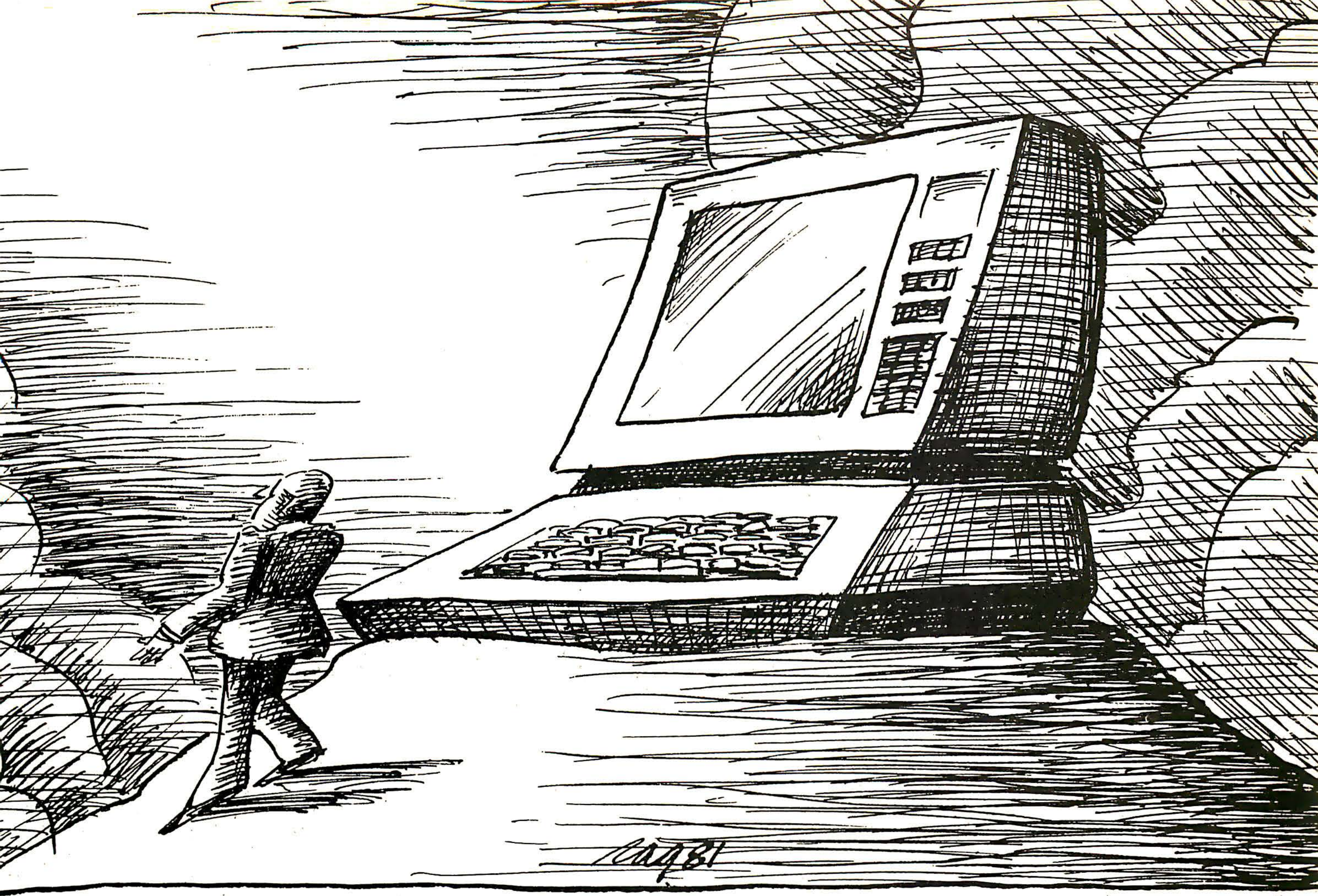


Figure 3: *Geometric interpretation of the fourth-order Runge-Kutta method for solving differential equations. Compartment size (x) is plotted versus time (t). Actual and predicted compartment sizes are shown.*



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discuss the fourth-order Runge-Kutta method. It is computationally more involved than Euler's method, but it incorporates less error into the prediction of the next compartment size (x_{t+1}). The geometric interpretation of this method is shown in figure 3.

As with the Euler method, knowing the present compartment value (x_t), you want to predict the next compartment value (x_{t+1}). First, you find the slope (*XD*) of the line at time *t*. Then, as in Euler's method, you calculate the compartment size (*P*), but at time $t+½$. After you calculate the slope (*XP*) at *P*, make a second prediction of the compartment size (*Q*) at time $t+½$. After you calculate the slope (*XQ*) at *Q*, make a third prediction of the compartment size (*R*), but at time $t+1$. Again, calculate the slope (*XR*). Next, take a weighted average of all the slopes you calculated and determine your final prediction of the compartment size (x_{t+1}) at time $t+1$. As with Euler's method, the Runge-Kutta method incorporates some error into your predictions; however, the error is now proportional to the fourth power of the time step (Δt) and is greatly reduced. The error can be reduced further by decreasing the time step.

The algorithm for the fourth-order Runge-Kutta method is:

1. $\dot{\mathbf{X}}_t^D = f(\mathbf{X}_t, \mathbf{Z}_t, t)$
2. $\mathbf{X}_{t+½}^P = \mathbf{X}_t + \Delta t/2(\dot{\mathbf{X}}_t^D)$
3. $\dot{\mathbf{X}}_{t+½}^P = f(\mathbf{X}_{t+½}^P, \mathbf{Z}_{t+½}, t+½)$
4. $\mathbf{X}_{t+½}^Q = \mathbf{X}_t + \Delta t/2(\dot{\mathbf{X}}_{t+½}^P)$
5. $\dot{\mathbf{X}}_{t+½}^Q = f(\mathbf{X}_{t+½}^Q, \mathbf{Z}_{t+½}, t+½)$
6. $\mathbf{X}_{t+1}^R = \mathbf{X}_t + \Delta t(\dot{\mathbf{X}}_{t+½}^Q)$
7. $\dot{\mathbf{X}}_{t+1}^R = f(\mathbf{X}_{t+1}^R, \mathbf{Z}_{t+1}, t+1)$
8. $\mathbf{X}_{t+1} = \mathbf{X}_t + \Delta t(⅙(\dot{\mathbf{X}}_t^D) + ⅓(\dot{\mathbf{X}}_{t+½}^P) + ⅓(\dot{\mathbf{X}}_{t+½}^Q) + ⅙(\dot{\mathbf{X}}_{t+1}^R))$

Listing 1: *Compucolor II Disk BASIC 8001 program segment of Euler integration algorithm.*

```
190 REM  ********** START SIMULATION  ******************
195 FOR IJ=1 TO 100
200 DT=1/KK
210 REM  ********** START EULER INTEGRATION LOOP *******
215 FOR JJ=1 TO KK
220 FOR I=0 TO N
230 AX(I)=0
240 FOR J=0 TO N: AX(I)=AX(I)+A(I,J)*X(J): NEXT J
250 FOR K=0 TO NN: AX(I)=AX(I)+B(I,K)*Z(K): NEXT K
260 NEXT I
270 FOR I=0 TO N: X(I)=X(I)+DT*AX(I): NEXT I
275 NEXT JJ
280 FOR I=0 TO N: XX(IJ,I)+X(I): NEXT I
290 NEXT IJ
300 REM  ********** END OF SIMULATION *****************
```

If you wish to reduce the error in the algorithm, you can decrease the time step (Δt), perform the algorithm several times, and save the last prediction of the compartment size. The Runge-Kutta integration method is incorporated into the GLM program in listing 2.

General Linear Model Program

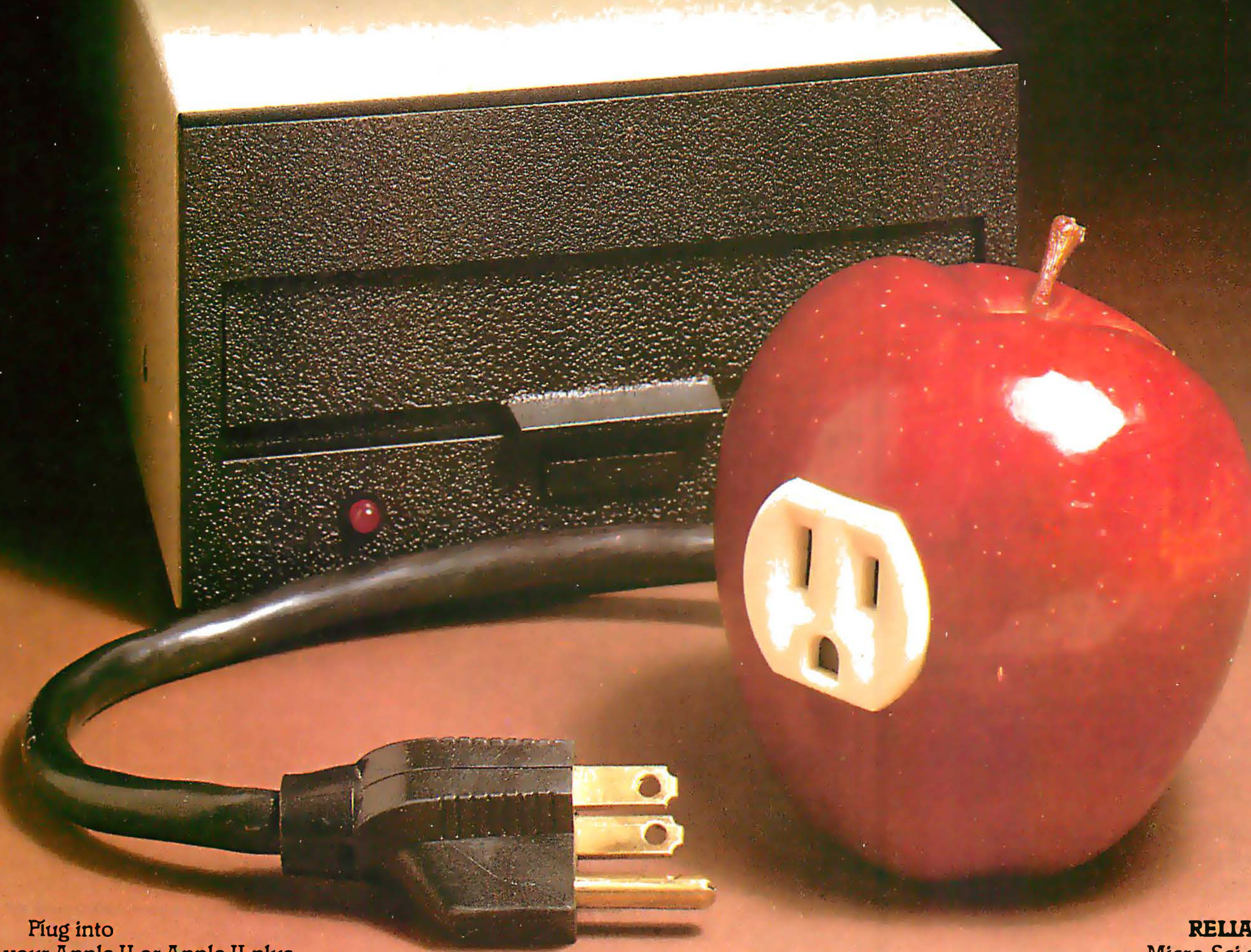
So far, I have discussed the general linear model form and two different algorithms for the numerical solution of differential equations. I have combined these two topics and written a general-user program for mathematically modeling a system of components described by linear differential equations, solved for 100 time increments with a Runge-Kutta integration algorithm. This program was written in Disk BASIC and is given in listing 2. To use this program, you enter the number of compartments in and environmental inputs to your system, an intercompartmental rate coefficient matrix (**A**), the initial compartment values, an input coefficient matrix (**B**), and the environmental input values. You must also enter the desired number of iterations of the Runge-Kutta algorithm. This value is the reciprocal of the

Text continued on page 86

PLOT 2	Enter graph-plotting mode
PLOT 2, X, Y	Point at X,Y
PLOT 2, 242, X, Y	Vector to X,Y
PLOT 2, 250, X0, Y, XM	Horizontal bar at Y from X0 to XM
PLOT 2, 246, Y0, X, YM	Vertical bar at X from Y0 to YM
PLOT 3, T, L	Cursor to tab T at line L
PLOT 6, C	Defines the color of both the foreground and background
PLOT 8	Cursor to home
PLOT 9	Tab 8 spaces
PLOT 10	Line feed (move cursor down one line)
PLOT 11	Erase line
PLOT 12	Erase page
PLOT 14	Double-height text
PLOT 15	Normal-height text, with blink mode off
PLOT 16 thru PLOT 23	Changes color of foreground or background (whichever is active)
PLOT 27, 4: PRINT "[disk commands]": PLOT 27, 27	Execute floppy-disk command
PLOT 27, 10	Write text vertically
PLOT 27, 24	Write text horizontally
PLOT 28	Cursor up
PLOT 29	Enable background color
PLOT 31	Blink on
PLOT 255	Cancel graph-plotting mode

Table 1: *The use of the PLOT command in Disk BASIC 8001 (for the Compucolor II). This information will help explain certain parts of listing 2, if you convert that program to another microcomputer.*

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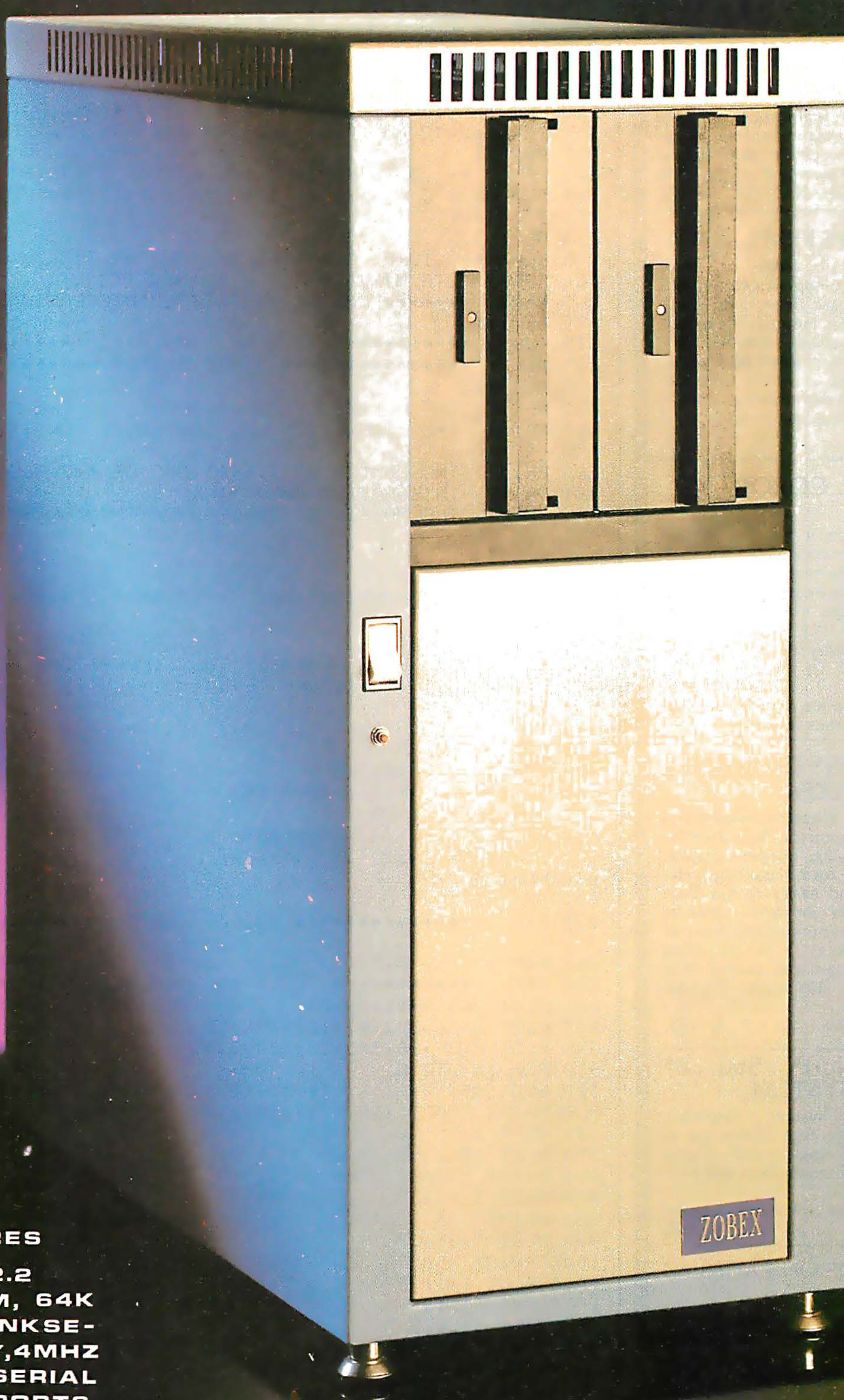
Listing 2: *A general-user program written in Disk BASIC 8001 for mathematical modeling with a system of time-invariant linear differential equations. The equations are solved for 100 user time increments with a fourth-order Runge-Kutta integration algorithm. As the program is written, the simulation results are scaled and plotted versus time on a video monitor (Compucolor II microcomputer). This section of the program will have to be modified for other microcomputer systems. See table 1 for further information on the PLOT command.*

```
10 REM    **** GENERAL LINEAR MODEL SIMULATION PROGRAM *****
11 REM    *********** WITH RUNGA-KUTTA INTEGRATION ***********
20 REM    ************** BY RANDALL E. HICKS ******************
21 REM    ***************** COPYRIGHT 1980 *******************
24 PLOT 12
25 PRINT "GIVEN:"
30 PRINT "1) THE NUMBER OF MODEL COMPARTMENTS"
35 PRINT "2) THE NUMBER OF ENVIRONMENTAL INPUTS"
40 PRINT "3) A MATRIX OF INTERCOMPARTMENTAL RATE COEFFICIENTS"
42 PRINT "4) A VECTOR OF INITIAL COMPARTMENT SIZES"
45 PRINT "5) A MATRIX OF ENVIRONMENTAL INPUT COEFFICIENTS"
47 PRINT "6) A VECTOR OF ENVIRONMENTAL INPUT SIZES  AND"
50 PRINT "7) THE NUMBER OF ITERATIVE INTEGRATION STEPS --"
51 PRINT
52 PRINT "THIS PROGRAM WILL USE A SYSTEM OF TRANSITION"
53 PRINT "EQUATIONS TO SIMULATE THE BEHAVIOR OF YOUR SYSTEM"
54 PRINT "USING A RUNGE-KUTTA INTEGRATION ALGORITHM WITH THE"
55 PRINT "OUTPUT PLOTTED AS A GRAPH ON THIS TERMINAL!"
74 PRINT
75 INPUT "HOW MANY COMPARTMENTS IN YOUR MODEL (N=1,7)?";N
80 N= N- 1:PRINT
85 INPUT "HOW MANY INPUT ENVIRONMENTS IN YOUR MODEL (N=1,3)?";NN
90 NN= NN- 1
95 DIM A(N,N),B(N,NN),XX(100,N),X(N),AX(N),XD(N),XP(N),XQ(N),XR(
N),Z(NN)
100 DIM BB(N),S(N),P(N)
110 PRINT "ENTER MATRIX OF INTERCOMPARTMENTAL RATE"
115 PRINT "COEFFICIENTS -- ROW BY ROW, ONE COLUMN AT A TIME."
120 FOR I= 0TO N
125 FOR J= 0TO N:INPUT A(I,J):NEXT J
130 NEXT I
135 PRINT "ENTER INITIAL COMPARTMENT VALUES"
140 FOR I= 0TO N:INPUT XX(0,I):NEXT I
145 PRINT "ENTER YOUR MATRIX OF ENVIRONMENTAL INPUT"
146 PRINT "COEFFICIENTS"
150 FOR I= 0TO N
155 FOR J= 0TO NN:INPUT B(I,J):NEXT J
160 NEXT I
165 PRINT "ENTER THE SIZES OF YOUR ENVIRONMENTAL INPUTS"
170 FOR J= 0TO NN:INPUT Z(J):NEXT J
175 PRINT "ENTER THE NUMBER OF ITERATIONS OF THE ALGORITHM"
176 PRINT "BEFORE INTEGRATION COMPLETION.":INPUT KK
180 REM    ********* STORE INITIAL COMPARTMENT VALUES *********
185 FOR J= 0TO N:X(J)= XX(0,J):NEXT J:PLOT 12
190 REM    *************** START SIMULATION ********************
195 FOR IJ= 1TO 100
200 DT= 1/ KK
205 REM    ********* START ITERATIVE INTEGRATION LOOP *********
210 FOR JJ= 1TO KK
215 REM    ********** START RUNGA-KUTTA INTEGRATION ************
217 REM    ** COMPUTE DX/DT AT TIME J-1 **
220 FOR I= 0TO N
221 XD(I)= 0
225 FOR J= 0TO N:XD(I)= XD(I)+ A(I,J)* X(J):NEXT J
230 FOR K= 0TO NN:XD(I)= XD(I)+ B(I,K)* Z(K):NEXT K
231 NEXT I
240 REM   ** COMPUTE FIRST ESTIMATE OF STATE(P) AT TIME IJ-1/2 **

245 FOR I= 0TO N:AX(I)= X(I)+ (DT/ 2)* XD(I):NEXT I
250 REM    ** COMPUTE DX/DT AT P **
255 FOR I= 0TO N
256 XP(I)= 0
260 FOR J= 0TO N:XP(I)= XP(I)+ A(I,J)* AX(J):NEXT J
261 FOR K= 0TO NN:XP(I)= XP(I)+ B(I,K)* Z(K):NEXT K
265 NEXT I
270 REM   ** MAKE SECOND ESTIMATE OF STATE(Q) AT TIME IJ-1/2 **
275 FOR I= 0TO N:AX(I)= X(I)+ (DT/ 2)* XP(I):NEXT I
280 REM    ** COMPUTE DX/DT AT Q  **
```

Listing 2 continued on page 84

MULTIUSER



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Listing 2 continued:

```
285 FOR I= 0TO N
286 XQ(I)= 0
290 FOR J= 0TO N:XQ(I)= XQ(I)+ A(I,J)* AX(J):NEXT J
300 FOR K= 0TO NN:XQ(I)= XQ(I)+ B(I,K)* Z(K):NEXT K
310 NEXT I
320 REM  ** MAKE ESTIMATE OF STATE(R) AT TIME J **
330 FOR I= 0TO N:AX(I)= X(I)+ DT* XQ(I):NEXT I
335 REM   ** COMPUTE DX/DT AT R **
340 FOR I= 0TO N
344 XR(I)= 0
345 FOR J= 0TO N:XR(I)= XR(I)+ A(I,J)* AX(J):NEXT J
350 FOR K= 0TO NN:XR(I)= XR(I)+ B(I,K)* Z(K):NEXT K
355 NEXT I
360 REM   ** COMPUTE FINAL VALUES FOR STATE AT TIME J **
364 FOR I= 0TO N:X(I)= X(I)+ DT* (XD(I)/ 6+ XP(I)/ 3+ XQ(I)/ 3+
XR(I)/ 6):NEXT I
370 NEXT JJ
375 REM  ** STORE COMPARTMENT SIZES AT TIME J IN MATRIX **
380 FOR I= 0TO N:XX(IJ,I)= X(I):NEXT I
385 REM   ******** END OF ITERATIVE INTEGRATION LOOP **********
390 NEXT IJ
395 REM   ************* END OF SIMULATION *************************
405 REM   **************** START OUTPUT **************************
409 PLOT 12
410 PRINT "THE NUMBER OF COMPARTMENTS IN THE MODEL IS:";N+ 1
415 PRINT "THE SIMULATION HAS CONTINUED FOR 100 USER TIME UNITS.
"
420 PRINT "THE NUMBER OF ITERATIONS OF THE ALGORITHM FOR EACH"
421 PRINT "INTEGRATION WAS: ";KK
425 PRINT "THE MATRIX OF INTERCOMPARTMENTAL RATE COEFFICIENTS IS
: "
430 PRINT
435 FOR I= 0TO N
440 FOR J= 0TO N:PRINT TAB( J* 10);A(I,J);:NEXT J:PRINT :PRINT
445 NEXT I
450 PRINT :PRINT
455 PRINT "TO SEE A GRAPH OF THE SIMULATION, ENTER CONT AND"
460 PRINT "HIT THE RETURN KEY."
500 END
610 FOR I= 0TO N:BB(I)= XX(0,I):S(I)= XX(0,I):NEXT I
620 FOR J= 0TO N
630 FOR I= 1TO 100
640 IF BB(J)> XX(I,J)THEN 660
650 BB(J)= XX(I,J)
660 IF S(J)< XX(I,J)THEN 680
670 S(J)= XX(I,J)
680 NEXT I
690 NEXT J
830 REM   *************** END OF SEARCH ***********************

860 FOR I= 0TO N:P(I)= 99.0/ (BB(I)- S(I)):NEXT I
870 REM   ************ SCALE VALUES CALCULATED ****************
880 PLOT 12,30,16,29,23
890 PLOT 2,26,25,242,127,25,255
900 PLOT 2,26,26,242,26,127,255
910 FOR I= 0TO N
920 PLOT 15,17+ I,3,(I* 10+ 13),30
930 PRINT "CMPT";SPC( 1);I+ 1
931 NEXT I
950 PLOT 15,23,3,32,28
960 PRINT "TIME (USER UNITS)"
970 PLOT 3,13,27
980 PRINT "0"
990 PLOT 3,36,27
1000 PRINT "50"
1010 PLOT 3,61,27
1020 PRINT "100"
2000 FOR I= 0TO N
2010 PLOT 15,17+ I,3,0,I
2020 PRINT BB(I):NEXT I
2030 FOR I= 0TO N
2040 PLOT 15,17+ I,3,0,I+ 22
2050 PRINT S(I):NEXT I
2060 FOR J= 0TO N
2070 FOR I= 0TO 100:XX(I,J)= (XX(I,J)- S(J))* P(J)+ 1:NEXT I
2080 NEXT J
2105 REM   ********* START PLOT OF OUTPUT MATRIX **************
2110 FOR J= 0TO N
2120 PLOT 17+ J,2,26,XX(0,J)+ 26,255
2130 FOR I= 1TO 100
```

Listing 2 continued on page 86

Listing 2 continued:

```
2140 PLOT 2,(I- 1)+ 27,XX((I- 1),J)+ 27,253,(I- 1)+ 27,XX((I- 1)
,J)+ 27,I+ 27,XX(I,J)+ 27,255:NEXT I
2150 NEXT J
9999 END
READY
```

Text continued from page 80:

desired time step. The program will then simulate the system of compartments for 100 time units and plot a graph of the compartments versus time. To graph the compartment sizes, you must scale the simulation values and plot them on some output device. I have included code for this in listing 2, which will run unmodified on a Compucolor II microcomputer. If you intend to run this program on another computer, check to see if Disk BASIC 8001 coding is compatible with your system. See table 1 for information on the Compucolor PLOT command.

Using the GLM Program

When the Okefenokee swamp uplands hydrologic model is simulated with this program on a microcomputer (on an 8080 microprocessor), the execution time of the Runge-Kutta algorithm is 210 seconds. When Euler's method is used, the execution time is reduced to 51 seconds. This time savings can be beneficial, depending upon the computational accuracy of the microprocessor and systems software. It can be cost-effective to use the Euler algorithm if the computer computational error is larger than the difference in the error between the Euler and Runge-Kutta methods. To give you an idea of the memory requirements necessary for a simulation, the hydrologic model can be simulated with the program in listing 2 if your microcomputer has 8 K bytes of programmable memory.

You can solve the system of linear differential equations for the size of any compartment at any time t. When inputs (**Z**), rate (a_{ij}) and input (b_{ik}) coefficients are constant, and t is initially equal to 0, the solution is:

$$x_i(t) = \underbrace{e^{\lambda_i t}\, x_i(0)}_{\text{zero-input response}} + \underbrace{\left(\sum_{k=1}^{m} b_{ik}\, z_k\right) \int_0^t e^{\lambda_i [t-\zeta]} d\zeta}_{\text{zero-state response}}$$

where:

λ_i = eigenvalue of compartment i
= a_{ii} + behavior caused by intrasystem coupling

This is the general solution of the ordinary differential equations in the linear model. The solution has two distinct parts, which I call the zero-input response and the zero-state response. If you eliminate the zero-state response, then the solution of the equation will give you the values of each compartment when the system does not receive any environmental input (**Z**). This can be simulated by changing all the input coefficients (b_{ik}) to 0. In the case of the hydrologic model, you would, in effect, be asking, "How is the moisture in each compartment affected if there is no precipitation input?"

You can eliminate the zero-input response from the equation and ask, "How long would it take the system to come to steady-state conditions if there were no moisture within the system to begin with?" This would be simulated by setting the initial compartment values (x_i) to 0. Photo 1 shows the zero-input response of the hydrologic model simulated with the program in listing 2. Photo 2 shows the zero-state response of the hydrologic model simulated with the same program.

You can start the simulation with different compartment sizes, a different environmental input size, or change the intercompartmental rate or input coefficients, and see how any or all of these changes will affect the outcome. I suggest that you devise a model that can be described with linear differential equations and simulate it at steady-state conditions. A good domestic simulation would be a model of heat losses, subsidies, and circulation within your home. If you have a slant toward business, you can simulate the flow of material or information into, within, and out of a commercial enterprise. As long as all the compartments and flows can be described in the same units, almost any type of measure can be simulated. Once you have completed the steady-state simulation, you can experiment with the GLM program to suit your taste. If you want to make the model more realistic, you can program the inputs to the system as sine waves, square waves, exponential functions, or an impulse function, instead of being constantly added as they are now. You can also test a compartment's sensitivity to a certain parameter by varying that parameter over its range and noting the differences in the compartment.

One warning: you must always be careful to analyze your simulations and decide if they actually mimic the real-world situation *before* you make sweeping generalizations and claims that you can predict how a system will behave under any given set of circumstances. With a little imagination, interesting and sometimes eye-opening results will be seen in mathematical simulations. ■

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When speaking of the amount of information available on the Dialog system, the numbers become mind-boggling. Dialog has some *50 billion* bytes of information available on-line in some 130 individual data bases. That works out to a rough total of about forty million individual bibliographic abstracts and references (referred to as *citations*). If all the citations were printed on 8½- by 11-inch paper, the stack would reach higher than the Empire State building.

The newspaper and magazine indexes are among the most popularly oriented data bases—although Dialog also offers a number of specialized data bases for those in education, industry, applied science and technology, and social science and the humanities. Business information and forecasts are also available. Eighteen new data bases were added to the system in 1980, and at least a dozen more will be available by the end of the year. The system is available 110 hours a week in fifty countries, and all data bases are updated regularly. Each day tens of thousands of new citations are added. Also, if you wish to create your own private data bases for use on the system, Dialog provides this service.

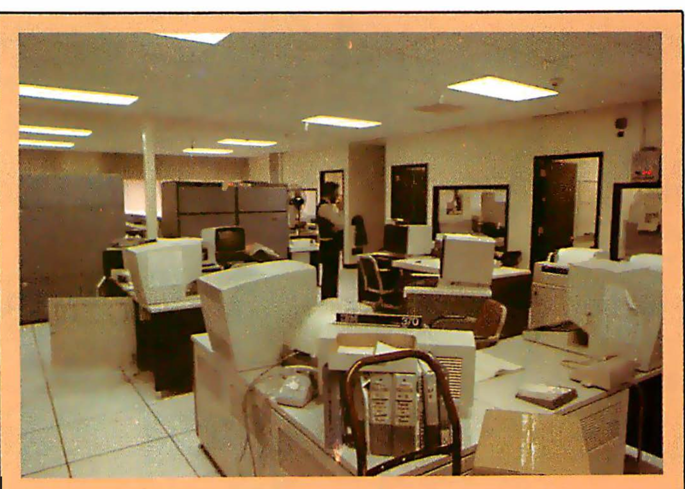
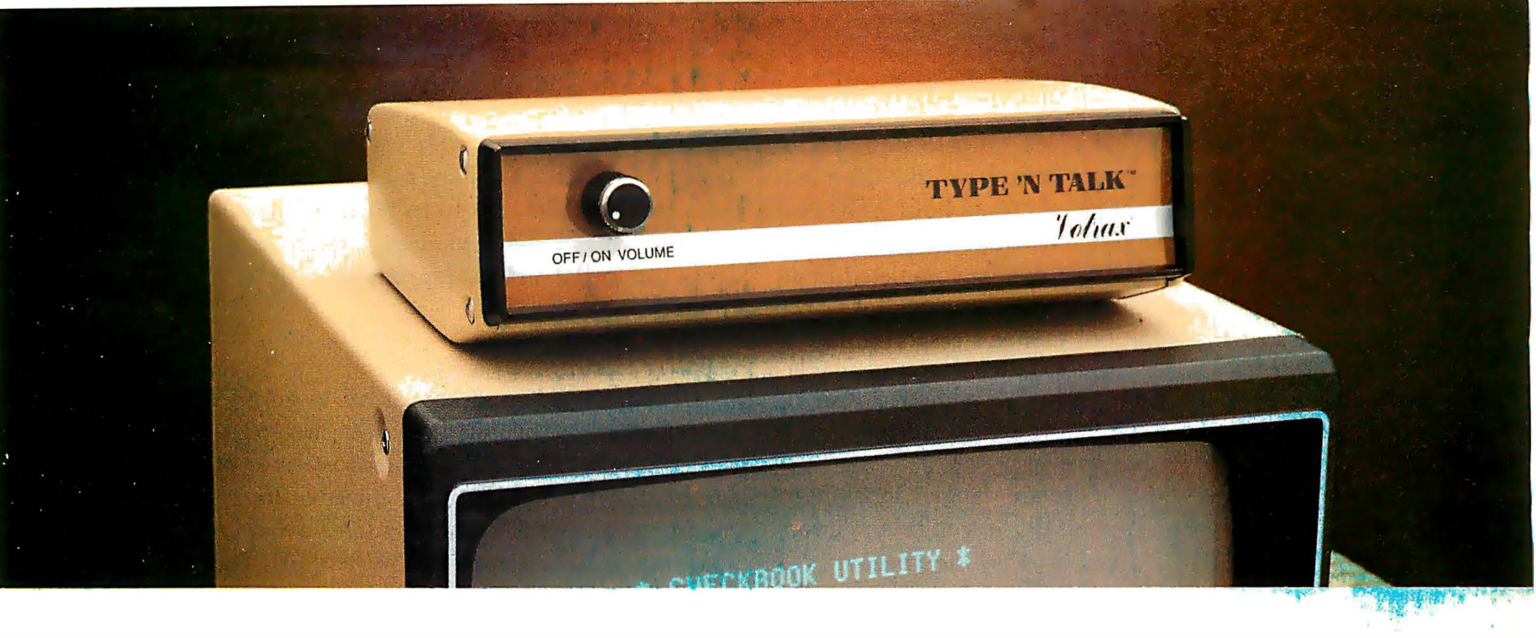


Photo 1: *The Lockheed Dialog computer room operator station. The system uses two mainframe computers—an IBM 3033 and an AS-9000 (sold in the United States by National Advanced Systems). Each computer contains a complete Dialog operating system; one handles Telenet calls, and the other Tymnet. Direct dial-in calls and leased lines are divided between the computers to even the loads. Because of the large amount of computer power available, the average wait for a response to a query is ten seconds—despite the fact that hundreds of users may be logged in during peak-use periods.*

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At first glance, Dialog seems expensive. Each data base has an individual charge ranging from $15 to $300 per hour of connect time. (It should be stressed that the most-used data bases cost an average of $50 an hour.) The cost becomes much more reasonable when you realize that an exhaustive search of any subject can be completed in an average of ten minutes. (Simple searches often take only a minute or two.) In addition, Dialog's response time is extremely fast because of the computer power available. Even during peak-use times, there is seldom a wait of more than ten seconds for the system to respond to a query.

It should be stressed that there are dangers inherent in using the Dialog system—especially if you're an "information junkie." It's extremely easy to become so enamored of Dialog's capabilities that you keep on calling up references and lose all track of time. The shock comes at the end of the month, when a very large bill arrives in the mail.

There are two ways to avoid this: the first is to *plan* what you'll be doing when you're logged on the system (explained in more detail below). The second is to keep track of your connect charges. Each time you log off or change data bases, Dialog prints an estimated charge. It's a good idea to keep a pad and a pencil next to your terminal and to keep a running total of charges at the end of every session.

Once you locate what you want, you can have the references and abstracts typed on your printer, although this can get expensive at the normal speed of 300 bps (bits per second). A better way is to have the citations printed by Dialog's off-line high-speed printer. The cost is minimal (normally $0.10 to $0.25 per citation) and they are mailed out the next day. Or, as mentioned above, you can order actual reprints directly from your terminal.

Dialog History

Dialog started modestly as an in-house research and development project at Lockheed in 1963. At that time, an information sciences laboratory was established to deal with what was then recognized as the coming "information explosion." Two years later, what was essentially the first truly interactive information retrieval system was on-line for internal company use.

In 1968, Lockheed won a contract from NASA to design, program, implement, and maintain a computerized index for the half-million documents produced by the American space program. Called RECON (Remote Console Information Retrieval Service), the development process enabled Lockheed to fine-tune the specialized information retrieval command language, which was called Dialog.

After gaining more experience preparing information retrieval systems for the AEC (Atomic Energy Commission), the US Office of Education, and a number of other organizations, Lockheed, in 1972, decided to offer commercial service and officially named the system Dialog.

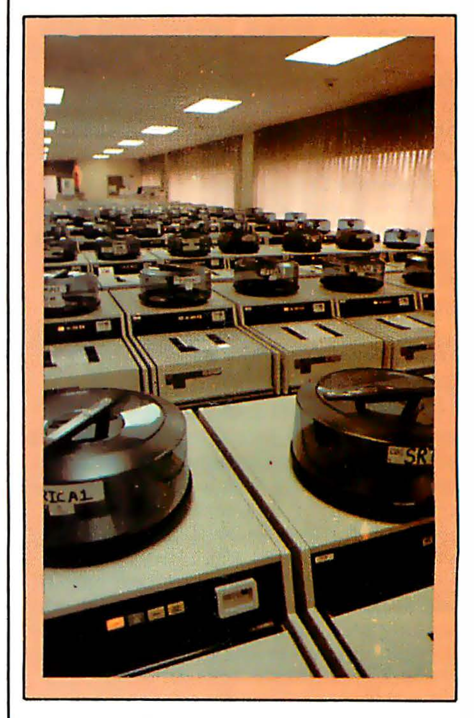


Photo 2: *Some of the 200 hard-disk drives used by the Dialog system. Most of the CDC (Control Data Corporation) drives hold 637 megabytes of data for a total of more than 50 billion bytes of on-line storage.*

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- hierarchical file systems
- device independent I/O
- four Gigabyte disk capacities
- full file protection
- inter-task communication via pipes
- I/O redirection
- task swapping
- full random-access files
- comprehensive shell command language

UniFLEX, structured for large-scale microprocessor systems, will not run with minimal systems and thus has avoided design compromise. (Off-the-shelf versions and OEM licenses are available.)

The FLEX™ Operating System

FLEX, a powerful, easy-to-use operating system designed for the 6800 and 6809 microprocessors, includes:

- dynamic filespace allocation
- random files
- batch job entry
- automatic space compression
- English error messages
- user environment control
- disk resident commands
- flexible device I/O
- printer spooling

Plus, FLEX can accommodate hard disks as well as floppies. The System is available off-the-shelf for a variety of systems and in a field-adaptable version. (OEM licenses available.)

FLEX and UniFLEX are trademarks of Technical Systems Consultants, Inc.

Support Software

Technical Systems Consultants offers a full line of state-of-the-art support software compatible to FLEX and UniFLEX, some of which are:

- native C and Pascal compilers for advanced programming
- extended BASIC for business and educational applications
- text editing and processing software
- sort/merge package for business applications
- variety of absolute and relocatable assemblers
- debug and diagnostic packages

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Sculpture by Joann Chaney

Industrial users continue to be Dialog's largest customers since much of the information in the specialized data bases (such as WORLD ALUMINUM ABSTRACTS or SURFACE COATING ABSTRACTS) is virtually unavailable anywhere else. Government agencies are also heavy users of Dialog's services—followed closely by educational institutions and libraries. Although personal computer users currently make up a very small percentage of Dialog customers, Lockheed officials told me they are in the process of adding more general-interest data bases to attract more individuals.



Photo 3: *IBM reel-to-reel tape with new and updated data waiting to be placed on the Dialog system. Some twenty tapes arrive at Dialog each day from the outside organizations that prepare the data bases. Each tape contains approximately 20,000 individual references and/or abstracts.*

A Visit to Dialog

Dialog's facilities are located in Palo Alto, California. As might be expected, the hardware needed to handle the enormous amount of information contained within the Dialog system has taken over a large portion of its building. For those used to working with a personal computer and a floppy disk or two, a visit to Dialog's computer room is a humbling experience. Two mainframe computers (an IBM 3033 and an AS-9000) are both on-line at all times. When I visited Dialog in January, the AS-9000 had just been put on-line. This so-called "super-mainframe" is sold in the United States by National Advanced Systems. Since its claimed speed far exceeds that of any other mainframe, a Dialog spokesman told me he expects it to greatly increase the system's capacity.

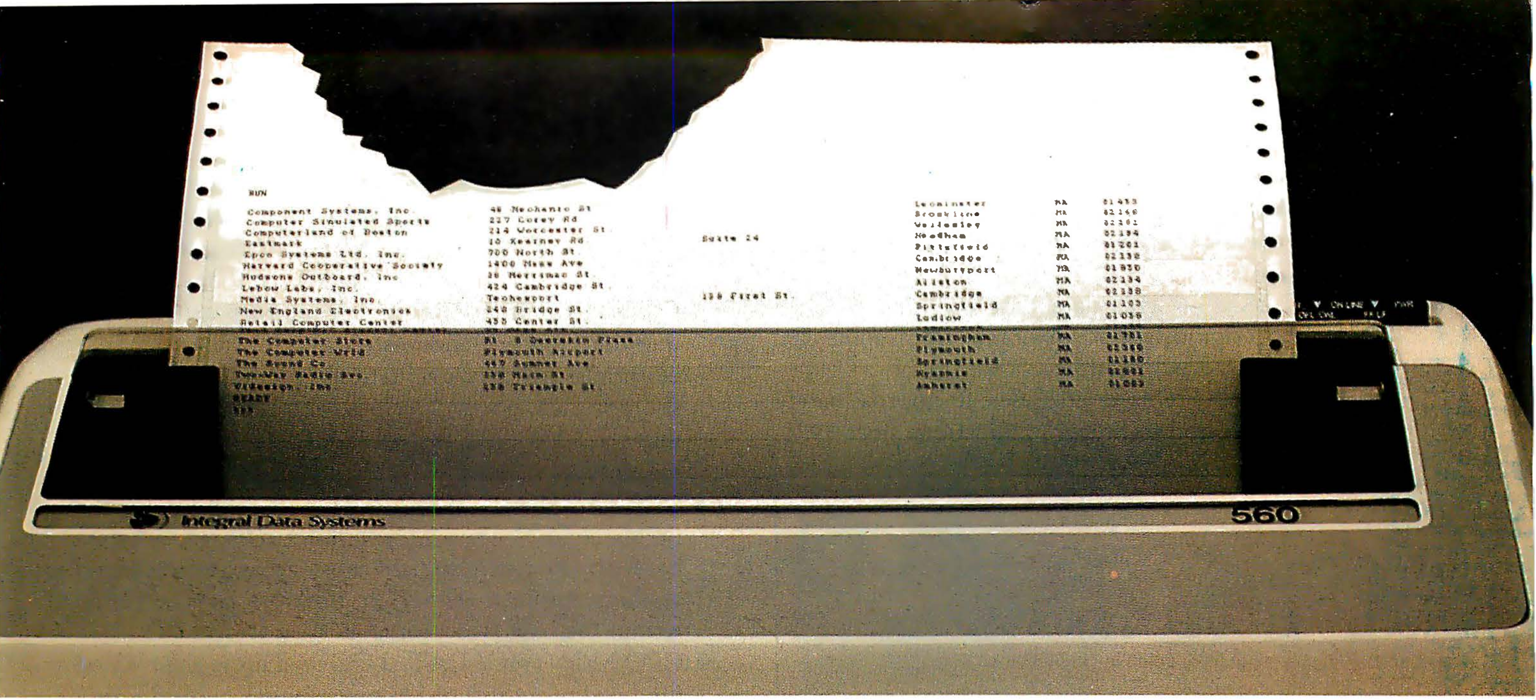
The most interesting part of Dialog's facilities are the hard-disk drives—some 200 of them. Most are CDC (Control Data Corporation) units capable of storing 637 megabytes per drive. Although direct dial-up numbers are available, the majority of Dialog users access the system through Tymnet or Telenet (national data-communication networks that have local telephone numbers in many communities).

Lockheed officials term Dialog a value-added *on-line service supplier.* All of the approximately 130 data bases are put together by seventy *data base producers* who have contractual agreements with Dialog. The process of producing and updating each of the data bases is a large one involving literally thousands of people who review publications, journals, and newspapers—many on a daily basis. Many reviewers work at home and transfer their citations to floppy disks, which are sent to the data base producers. The final step is to transfer all the citations to IBM magnetic tape. Between ten and twenty of these tapes, each containing about 20,000 new citations, arrive at Dialog headquarters every day. Before the information is added to the system, *every word* in all citations is indexed. This is one of the most powerful searching features of the system.

Popular Data Bases

Although many of Dialog's data bases are extremely specialized (such as AQUACULTURE, BHRA FLUID ENGINEERING, or PHARMACEUTICAL NEWS INDEX), a number of the existing data bases are of general interest or of special significance to BYTE readers. Among them are:

- ERIC — One of the first Dialog data bases available, ERIC (Educational Resources Information Center) indexes some 700 publications of interest to every segment of the educational profession. About 3000 citations are added every month.
- COMPENDEX — This data base contains abstracted information from approximately 2000 of the world's



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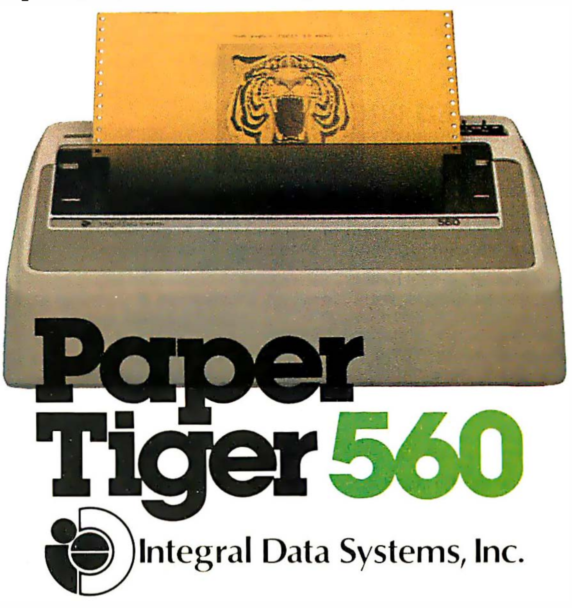
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*Suggested U.S. retail price.

engineering and technical journals since 1969.

- INSPEC — This data base is similar to COMPENDEX except it also abstracts scientific bulletins and contains bibliographic references from scientific indexes. Included is a special section of computer and control abstracts.
- ABI/INFORM — This data base contains management and administration abstracts from some 400 business-related publications.
- SCISEARCH — This is an index to approximately 2600 scientific and technical publications since 1974.



Photo 4: *IBM reel-to-reel tape drives used to load new and updated information into the Dialog disk drives.*

This data base contains bibliographic references only.

- MAGAZINE INDEX — Perhaps the most popularly oriented Dialog data base, this is a cover-to-cover index of about 370 popular American magazines since 1976 and contains some *300,000* citations. It's particularly useful for most general-purpose reference questions since it indexes all articles, news reports, editorials, product evaluations, biographical pieces, short stories, poetry, recipes, and reviews. Approximately 5000 citations are added to this data base monthly.
- SSIE CURRENT RESEARCH — Compiled by the Smithsonian Science Information Exchange, this data base lists and summarizes most government-funded research projects either in progress or completed within the past two years.
- GPO MONTHLY CATALOG — This is the catalog (updated monthly) of US government publications.
- ENERGYLINE — This data base contains bibliographical citations as well as abstracts on all aspects of energy.
- CONFERENCE PAPERS INDEX — This is an index to meetings and symposia on all scientific and technical fields. Also included are references to conference papers (many of which have never been published). This is a very large data base to which about 10,000 citations are added each year.
- NATIONAL FOUNDATIONS — This lists all US private foundations that award grants for charitable purposes.
- DISCLOSURE — This data base, updated weekly, provides extracts of reports filed with the SEC (Securities and Exchange Commission) by all publicly owned companies in the United States.
- NATIONAL NEWSPAPER INDEX — This data base contains front-to-back indexing of *The New York Times, The Wall Street Journal,* and *The Christian Science Monitor* since January 1, 1979. It contains bibliographical references to everything included in the papers, with the exception of advertisements, weather charts, stock market tables, crossword puzzles, and horoscopes. About 15,000 new citations are added monthly.
- NEWSEARCH — This is a *daily* update of the MAGAZINE INDEX, MANAGEMENT CONTENT, the LEGAL RESOURCE INDEX, and the NATIONAL NEWSPAPER INDEX; it is invaluable for locating references within days of an article's appearance.
- ENCYCLOPEDIA OF ASSOCIATIONS — This data base contains detailed information on approximately 15,000 national nonprofit organizations. Included are listings for professional societies, trade associations, labor unions, and cultural and religious organizations.
- STANDARD AND POOR'S NEWS — Provides extensive news coverage as well as financial reports on

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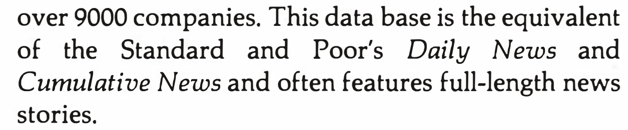




Photo 5: *The Xerox 9700 high-speed printer used by Dialog for off-line printing of references. The printer operates at two pages a second and offers Dialog users a considerable savings over having their references printed out while logged onto the system. The average cost of having references printed off-line and mailed to you is $0.10 to $0.25 per citation.*



Photo 6: *Dialog's customer-service area, where specially trained personnel are available to offer advice. They can be reached by calling a toll-free number.*



over 9000 companies. This data base is the equivalent of the Standard and Poor's *Daily News* and *Cumulative News* and often features full-length news stories.

- DIALINDEX — This is perhaps the most useful of the Dialog data bases and contains a collection of the file indexes for *all* data bases. DIALINDEX is a low-cost data base that allows you to ascertain which data bases contain the information you're searching for.
- NTIS — Compiled by the National Technical Information Service of the US Department of Commerce, this data base contains citations to more than 700,000 US reports covering government-sponsored research and development and engineering. Information on almost any subject imaginable is contained within this massive data base.

In addition, there are data bases covering psychology, chemistry, agriculture, medicine, biology, physics, and many other fields and disciplines. Dialog provides a free catalog of all the available data bases.

The Dialog staff and data base producers are continually adding new data bases to the system. By the end of this year, plans call for the addition of a biography index with over five million names, a book review index, an index of the Congressional Record, the Federal Index, a grants index, data from the Bureau of Labor Statistics, and Medline (a medical information data base designed for both physicians and consumers).

Accessing Dialog

There is no minimum fee or startup charges for the Dialog service. Once you've filled out an application and



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CHEMICAL INDUSTRY NOTES
DISCLOSURE
ECONOMICS ABSTRACTS INTERNATIONAL
EIS INDUSTRIAL PLANTS
EIS NON-MANUFACTURING ESTABLISHMENTS
FOREIGN TRADERS INDEX
MANAGEMENT CONTENTS
PHARMACEUTICAL NEWS INDEX
THE PREDICASTS GROUP
PTS F & S INDEXES
PTS INTERNATIONAL TIME SERIES
PTS INTERNATIONAL FORECASTS
PTS PROMT (Market Abstracts)
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PTS U.S. FORECASTS
TRADE OPPORTUNITIES
U.S. EXPORTS

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CRIS (Current Agricultural Research)
FOUNDATION DIRECTORY
FOUNDATION GRANTS INDEX
FROST & SULLIVAN DM²
GRANTS DATABASE
GPO MONTHLY CATALOG (Government Publications)
NATIONAL FOUNDATIONS
SSIE CURRENT RESEARCH

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APTIC (Air Pollution)
ENERGYLINE
ENVIROLINE
ENERGY INFORMATION
ENVIRONMENTAL PERIODICALS BIBLIOGRAPHY
POLLUTION ABSTRACTS

GOVERNMENT PUBLICATIONS
AMERICAN STATISTICS INDEX
CONGRESSIONAL INFORMATION SERVICE INDEX
GPO MONTHLY CATALOG
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NATIONAL NEWSPAPER INDEX
NCJRS (Criminal Justice)
NEWSEARCH
PAIS (Public Affairs)
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AIM/ARM (Vocational Education)
AMERICAN STATISTICS INDEX
CHILD ABUSE & NEGLECT
DISSERTATION ABSTRACTS
ERIC (Educational Research)
EXCEPTIONAL CHILD EDUCATION RESOURCES
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BHRA FLUID ENGINEERING
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CLAIMS/CHEM/UNITERM (Patents)
CLAIMS/CLASS (Patent Classification)
CLAIMS/U.S. PATENT ABSTRACTS
COMPENDEX (Engineering Index)
INPADOC (Patents)
INSPEC (Computers, Electronics)
ISMEC (Mechanical Engineering)
METADEX (Metals)
NATIONAL TECHNICAL INFORMATION SERVICE
NON-FERROUS METALS ABSTRACTS
PIRA (Paper, Printing, Packaging)
RAPRA (Rubber & Plastics)
SURFACE COATINGS ABSTRACTS
TRIS (Transportation)
WELDASEARCH
WORLD ALUMINUM ABSTRACTS
WORLD TEXTILE ABSTRACTS

Figure 1: *Available Dialog data bases as of February 1981. Eighteen new data bases were added to the system in 1980; about a dozen more are planned to be operational by the end of 1981.*

have been provided with a password, the easiest means of accessing the system is through either the Tymnet or Telenet networks. Currently, Tymnet charges $8 per hour and Telenet charges $5 per hour. The network connect charges are added to your Dialog monthly statement. (At the present time, Dialog bills monthly, but it is studying the possibility of billing through charge cards.) Dialog provides a list of telephone numbers and passwords/access numbers for both networks. If you have to make a toll call to access the networks, that's an additional charge. This expense is minimized, of course, for subscribers in Dialog's local area or those who have access to WATS (wide-area telephone service) lines. There are also direct-access lines to Dialog and incoming WATS lines are available at $15 per month.

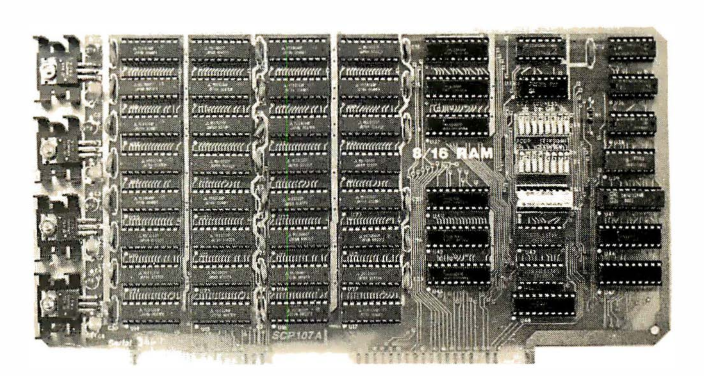
Using Dialog

There are a number of levels at which the Dialog system can be used. Most of the time, you'll find a simple search with a couple of terms the easiest way to go. A

Higher production volume and lower chip prices allow us to pass these savings on to you

RAM Prices SLASHED

16K BYTE 8/16 RAM



This fully static RAM board offers you the best of two worlds. Automatically switches between 8-bit or 16-bit operation, depending upon your CPU. High reliability, low noise design. 200 nsec. chips allow 8 Mhz. 8086 operation. Has extended addressing which can be disabled by a single switch. Prices: 1-9, $280; 10-19, $260.

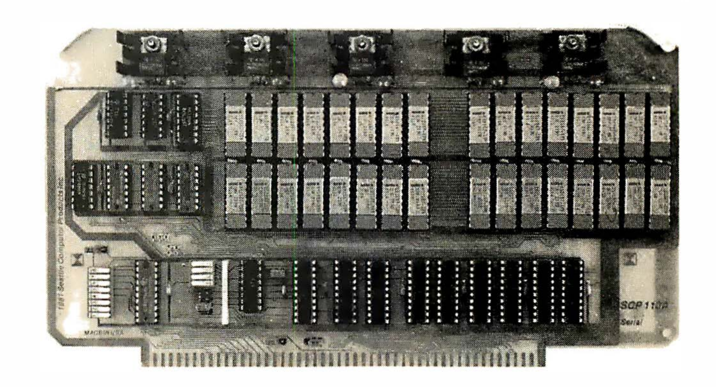
OTHER RAM SAVINGS

16K PLUS RAM—this fully static RAM has become the standard of the industry. It features 200 nsec. chips and Cromemco style bank select using port 40H. Addressable to any continuous 16K on 4K boundaries. Any 4K block may be disabled. High reliability, low noise design. Prices: 1-9, $280; 10-19, $260.

16K STANDARD RAM—this fully static RAM is frequently used by OEMs in systems which do not require bank select. High reliability, low noise circuits. Uses 200 nsec. chips. Addressable to any continuous 16K on 4K boundaries. Any 4K block may be disabled. Prices: 1-9, $265; 10-19, $245.

64K STATIC 8/16 RAM

AVAILABLE JULY 6—This state-of-the art board uses 2167 16K static 70/100 nsec. chips in a "power down" mode. This means you can expect the first 64K in a system to use 1.6 amps with subsequent boards using about .8 amps each. Built for the same high reliability you have come to expect from using our other boards. Has 24-bit extended addressing which can be disabled. Initial quantities will be limited—reserve yours now to ensure early delivery. Prices: 1-9, $1295; 10-19, $1195.



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CCS Asynchronous 7710A	139

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A/D D/A Board by Mtn. Comp.	319
Arith. Processor 7811 A or B	339
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COPYROM by Mtn. Comp.	51
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GPIB by CCS model 7490A	259
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Hayes Micromodem*	319
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Introl X-10 Controller Only	169
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Microsoft Z-80 Soft Card	295
Novation Cat Modem	159
Programmable Timer CCS 7440A	159
Prototyping Hobby Card	22
ROMWRITER by Mtn. Comp.	149
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SuperTalker Speech Synthesizer	239
Symtec Light Pen	214
Versa-Writer Digitizer Drawing System	209
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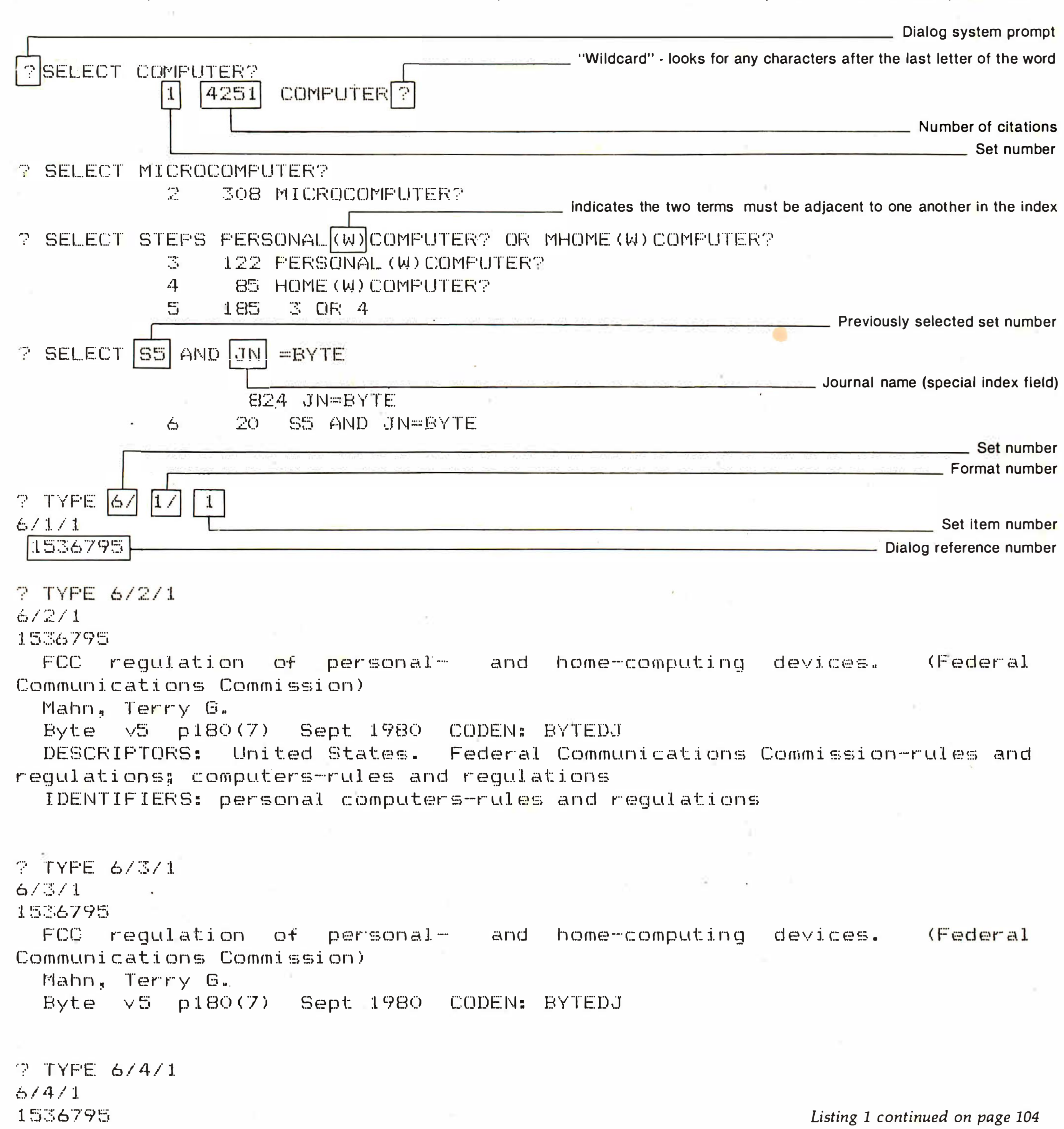


DIV. OF COMPUTER METRICS INC.

number of advanced searching functions are available; however, they probably won't be needed until you have quite a bit of experience on the system. Dialog's searching commands are simple, straightforward, and easy to learn. Dialog representatives do offer formal training classes on a regularly scheduled basis at locations throughout the country. However, they're mainly designed for those with no computer experience and those who will be using Dialog as a regular part of their job (such as librarians). New users are given some free time on the system in order to have an opportunity to get a feel for how Dialog works.

Text continued on page 106

Listing 1: *A typical search on the Dialog Information Retrieval Service—using the MAGAZINE INDEX data base. For the most efficient use of the system, as well as lower cost to the user, the* search strategy *(steps) should be planned on paper before logging in. See the text box of* Basic Dialog Commands *for a summary of the Dialog language. A SELECT statement can be up to 240 characters (when Boolean operators are used). Each search can create up to 98 sets, and there is a limit of one million citations per search.*




```
?SELECT COMPUTER?
          1   4251  COMPUTER?
? SELECT MICROCOMPUTER?
          2    308  MICROCOMPUTER?
? SELECT STEPS PERSONAL(W)COMPUTER? OR MHOME(W)COMPUTER?
          3    122  PERSONAL(W)COMPUTER?
          4     85  HOME(W)COMPUTER?
          5    185  3 OR 4
? SELECT S5 AND JN =BYTE
              824  JN=BYTE
          6     20  S5 AND JN=BYTE
? TYPE 6/1/1
6/1/1
1536795

? TYPE 6/2/1
6/2/1
1536795
   FCC regulation of personal- and home-computing devices. (Federal
Communications Commission)
   Mahn, Terry G.
   Byte  v5  p180(7)  Sept 1980  CODEN: BYTEDJ
   DESCRIPTORS: United States. Federal Communications Commission-rules and
regulations; computers-rules and regulations
   IDENTIFIERS: personal computers-rules and regulations


? TYPE 6/3/1
6/3/1
1536795
   FCC regulation of personal- and home-computing devices. (Federal
Communications Commission)
   Mahn, Terry G.
   Byte  v5  p180(7)  Sept 1980  CODEN: BYTEDJ


? TYPE 6/4/1
6/4/1
1536795
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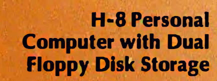
Listing 1 continued on page 104

You'll be a little richer after building one of these.

H-19 Professional Video Terminal



H-8 Personal Computer with Dual Floppy Disk Storage



H-11A 16-Bit Computer with Dual Floppy Disk Storage



Self-Instruction for Assembly and BASIC Programming



H-89 All-In-One Computer with Floppy Disk Storage

H-14 Serial Printer

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(In Canada write Heath Company, 1480 Dundas St. E., Mississauga, Ont. L4X 2R7)

CP-186

Listing 1 continued:

```
   FCC regulation of personal- and home-computing devices. (Federal
Communications Commission)

? TYPE 6/3/1-20
6/3/1
1536795
   FCC regulation of personal- and home-computing devices. (Federal
Communications Commission)
   Mahn, Terry G.
   Byte  v5  p180(7)  Sept 1980  CODEN: BYTEDJ

6/3/2
1522838
   The Heath H-89 computer. (evaluation)
   Dahmke, Mark
   Byte  v5  p46(6)  Aug 1980  CODEN: BYTEDJ
   illustration

6/3/3
1508584
   Bills introduced in Congress. (dealing with personal computers)
   6)
   Byte  v5  p186(6)  June 1980  CODEN: BYTEDJ

6/3/4
1508580
   A personal computer on a student's budget.
   Johnston, J.C.
   Byte  v5  p138(6)  July 1980  CODEN: BYTEDJ
   illustration
              .                     .
              .                     .
              .                     .
6/3/17
1017592
   User's report: the PET 2001. (evaluation)
   Fylstra, Dan
   Byte  v3  p114(9)  March 1978

6/3/18
1017578
   Personal computers in a distributed communications network.
   Steinwedel, Jeff; S
   Byte  v3  p80(8)  Feb 1978

6/3/19
1017469
   Speech recognition for a personal computer system.
   Boddie, James R.
   Byte  v2  p64(7)  July 1977

6/3/20
1017464
   Personal computer network.
   Byte  v2  p59(2)  Sept 1977

? END/SAVE
Serial# [40DI]
```

Serial number of search strategy (steps used)

Listing 1 continued on page 106

POWER-ONE D.C. POWER SUPPLIES

Our customers select their favorite models

The choice wasn't easy. Not with 105 open frame linears and a full switcher line to choose from. Still, the top models of the past year — proudly pictured below — have been named.

Actually, this is a statement of Power-One's most popular D.C. power supplies — as determined by our customers. Obviously, applications vary widely, from small floppies and micro-computers to large main-frame systems.

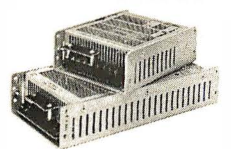
But one thing they all have in common. They're built by Power-One. Which means the most reliable power supplies available, at the lowest cost possible.

So take a look at our entire line. Send for our new 1981 Catalog and Facilities Brochure for details.

Switchers

- Hi-Tech Design
- High Efficiency - 75% min.
- Compact/Light Weight
- 115/230 VAC Input
- 20 msec Hold-up
- Totally Enclosed Packaging
- Two Year Warrantee
- 24 Hour Burn-in

SINGLE OUTPUT

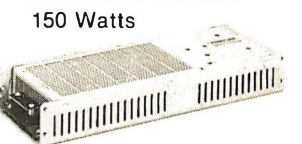


5V to 24V Models

SD, 60W : $115.00
SF, 100W : $170.00
SK, 200W : $250.00

MULTIPLE OUTPUT

150 Watts



5V @ 20A — -12V @ 3A
12V @ 5A — 5V to 24V @ 3.5A User Selectable

SHQ-150W : $295.00

QUME PRINTER SUPPLY



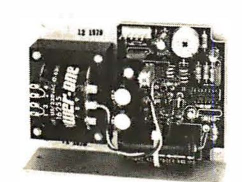
5V @ 10A
± 15V @ 4.5A/16A Peak

SP305 : $345.00

Disk-Drive

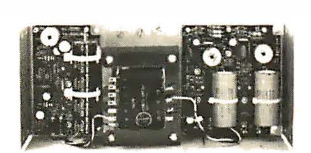
- Powers Most Popular Drives
- 7 "Off the Shelf" Models
- Powers Drives & Controller
- UL & CSA Recognized
- 115/230 VAC Input

5¼" FLOPPY SUPPLIES



CP340, 1 Drive : $44.95
CP323, Up to 4 Drivers : $74.95

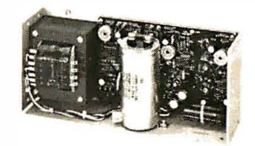
8.0" FLOPPY SUPPLIES



CP205, 1 Drive : $69.95
CP206, 2 Drives : $91.95
CP162, Up to 4 Drives : $120.00

WINCHESTER SUPPLIES

2 Models to Power any Manufacturer's Drive

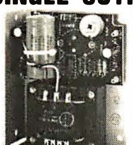


CP379, CP384 : $120.00

Open-Frame Linear

- Industry Standard Packages
- 115/230 VAC Input
- ±.05% Regulation
- Two Year Warrantee
- UL & CSA Recognized
- Industry's Best Power/Cost Ratio

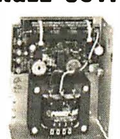
SINGLE OUTPUT



5V @ 3A — 24V @ 1.2A
12V @ 1.7A — 28V @ 1.0A
15V @ 1.5A — 250V @ 0.1A

HB Series : $24.95

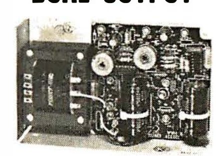
SINGLE OUTPUT



5V @ 6A — 24V @ 2.4A
12V @ 3.4A — 28V @ 2.0A
15V @ 3.0A — 48V @ 1.0A

HC Series : $44.95 to $49.95

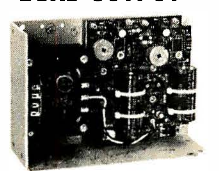
DUAL OUTPUT



± 12V @ 1.0A or
± 15V @ 0.8A

HAA15-0.8 : $39.95

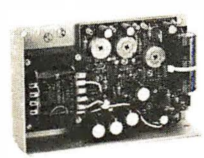
DUAL OUTPUT



± 12V @ 1.7A or
± 15V @ 1.5A

HBB15-1.5 : $49.95

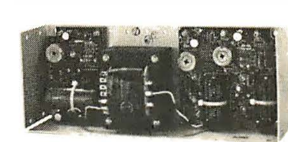
TRIPLE OUTPUT



5V @ 2A
± 9V to ± 15V @ 0.4A

HTAA-16W : $49.95

TRIPLE OUTPUT



5V @ 3A
± 12V @ 1A or
± 15V @ 0.8A

HBAA-40W : $69.95

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Listing 1 continued:

```
? BEGIN [111]----------------------------------- Dialog file number
File111:National Newspaper Index
(Copr. IAC)
          Set  Items  Description  (+=OR;*=AND;-=NOT)
          ---  -----  --------------------------------

? .EXECUTE [4QDI]------------------------------- Execute previous search strategy
               1588 COMPUTER?
                  7 MICROCOMPUTER?
                 23 PERSONAL(W)COMPUTER?
                 19 HOME(W)COMPUTER?
                 35  3 OR 4
                  0 JN=BYTE

? BEGIN 47
File47*:Magazine Index -
(Copr. IAC)
          Set  Items  Description  (+=OR;*=AND;-=NOT)
          ---  -----  --------------------------------

? [EXPAND COMPUTER]----------------------------- Find all index terms alphabetically close to specified term
Ref   Index-term                 Type Items RT
E1    COMPUTATIONAL COMPLEXITY            1
E2    COMPUTATIONS-----------------        1
E3    COMPUTE----------------------        4
E4    COMPUTED---------------------        3
E5    COMPUTEK---------------------        2
E6   -COMPUTER---------------------     3228
E7    COMPUTER AIDED DESIGN---           24
E8    COMPUTER AND BUSINESS
        EQUIPMENT MANUFACTUR--            2
E9    COMPUTER AND COMMUNICATI
        ONS ASSOCIATION--------           1
E10   COMPUTER AND COMMUNICATI
        ONS INDUSTRIES ASS----            1
E11   COMPUTER AND SYSTEMS
        ENGINEERING LTD.-------           1
E12   COMPUTER ANIMATION-------           5
E13   COMPUTER APPLICATIONS
        CORP.------------------           2
E14   COMPUTER ARCHITECTURE----           2
```

Text continued from page 102:

Searching

A Dialog spokesman stressed to me the importance of developing a general search *strategy*. This means sitting down with paper and pencil *before* logging on to the system, organizing questions or topics into logical groups, and then combining the groups through the use of logical (Boolean) relationships. This is an important point since wasting time with an inefficient searching strategy can become very expensive.

Since every word in every citation is indexed, the key to efficient searching is being as specific as possible. For example, the MAGAZINE INDEX contains 1.3 million individual citations; searching for all references to COMPUTER? (the ? is a "wildcard" character that matches any letters at the end of the word) yielded 4251 citations (see listing 1). Obviously, steps must be taken to pare down the number of citations by being much more specific. Searching for MICROCOMPUTER? yielded 308 citations, still a healthy number. HOME(W)COMPUTER? OR PERSONAL(W)COMPUTER? yields 185 citations. (The (W) indicates the two words must be adjacent to one another.)

Besides the every-word indexing, all Dialog data bases contain special indexes that vary from file to file. If I wish to search for all home and personal computer articles in BYTE, I can AND my set of 185 citations with JN= BYTE—giving me a total of twenty citations. There are also special indexes which allow you to specify publication year, author name, article type (such as product review), or a number of other special features. Obviously, sitting down beforehand and planning your search

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Basic Dialog Commands

Although there are many commands available in the Dialog searching language, a small number are the only ones used for the majority of searches. They include:

- *EXPLAIN — an on-line help file that provides a detailed description of any specified command. The file also contains a list and description of all available data bases and system news.*
- *SELECT — sets aside index terms or groups of terms you specify into numbered sets (up to 98). More than one term can be combined into a single SELECT statement by inserting Boolean operators between terms. For example:*

  SELECT PETROLEUM AND PRICES AND OPEC AND PY=1979

  A command line can contain up to 240 characters.
- *SELECT STEPS — similar to SELECT, except that each individual item in a single command statement is assigned its own set number.*
- *EXPAND — used to display a listing of index terms that are alphabetically close to the term entered. Each term is given a reference number that can be SELECTed, and the number of individual entries for each term is listed.*
- *TYPE — displays records on-line from the sets you've previously retrieved. A number of different formats and ranges can be entered. For example, the Dialog reference number, the title only, or the full record can be displayed.*
- *PRINT — orders the specified search results to be printed off-line using Dialog's high-speed printer. The printouts are normally received in three to four days. If you've retrieved a large number of references and/or abstracts, having them printed off-line is considerably less expensive than using connect time to dump them to your own printer.*
- *END/SAVETMP — ends a search session and saves the search strategy (individual steps) you've used in an individual data base. The strategy is saved until the end of the calendar day and in that period can be used in other data bases by using the .EXECUTE command.*
- *.EXECUTE — searches a data base using the search strategy saved by the END/SAVETMP command. This eliminates the time and expense of having to enter individual steps every time a different data base is entered.*
- *END/SDI — ends a search session and instructs the Dialog system to run the same search strategy in the specified file each time the file is updated. If new information is found, it is printed off-line and mailed to you. (This service is not available on all Dialog files.)*
- *KEEP — saves the references and/or abstracts you specify in a special set from which documents may be ordered using DialOrder.*
- *.ORDER — automatically orders reprints specified by the KEEP command. The document supplier can be specified from a list supplied by Dialog.*

For more information on Dialog and an application for service, contact:

Dialog Information Retrieval Service
Department 52-89/BT
3460 Hillview Ave
Palo Alto CA 94304
(800) 227-1617, ext 518
California (800) 772-3545, ext 518

makes the process proceed much more quickly, smoothly—and inexpensively.

If you have problems finding the correct search strategy, there is a toll-free hotline number to Dialog's Customer Service Department, which is open twelve hours a day. Besides helping beginning searchers, there is a specialist on each data base available who can help with a particularly complicated search.

Other Features

Dialog allows you to reconnect to the system within ten minutes of a disconnect (such as being dropped by one of the networks). Up until this time limit, all the set you've created will still be in the user area. Unfortunately, if the disconnect lasts longer, you'll have to start again from the beginning.

Users who wish to keep their own private data bases on the Dialog system can do so through the Private File Service. The cost for storage of data is $12 per million characters per month. Currently, in order to take advantage of the Private File Service, users must supply Dialog with IBM reel-to-reel tapes. However, Dialog's staff is in the process of developing a method that will enable users to build up their personal data bases from their own terminal.

Summary

Dialog is an invaluable service for anyone who needs to locate information on any imaginable subject from aardvarks to zymurgy. (Remember, the system is *not* designed to be everything to all people. Unlike the Source or Micronet, you can't play games or get the latest news from one of the wire services; not only are those services unavailable, but the cost of just "browsing" adds up very quickly.) Although the cost of the service seems expensive, the system's speed, efficiency, and interactive nature make it a net time and money saver when it's used for its intended purpose—finding references to information.

A Dialog staffer put it this way: "On the system, searching is an adventure." I can add that this adventure is *much* less frustrating than the computer game of the same name.■

A Computer-Based Laboratory Timer

John Gibson
Physics Department
Alma College
Alma MI 48801

Accurate time measurement is a fundamental requirement of every elementary physics laboratory. Thanks to modern electronics, most laboratories now use digital timing devices that are activated by photocells or microswitches. This is a great improvement over the hand-operated mechanical stop-clocks that were prevalent only a few years ago, but most electronic timers are still unsatisfactory in one important respect: only the most sophisticated (and expensive) are able to rapidly make and record a succession of elapsed-time measurements.

Data acquisition and logging are natural provinces of the microcomputer. Since small microcomputers and microcomputer trainers are now so widely available, it is only natural to try to adapt them for use in a variety of laboratory measurements. This article will show how a very modest microcomputer can be wired and programmed for use as a sophisticated laboratory timer.

First we will examine the system-independent design considerations for a microcomputer-based, two-channel, data-logging, millisecond timer. Then we will build this design on a Heath ET-3400 microprocessor trainer used with the ETA-3400 expansion accessory.

The Programmable Timer

The heart of this design is a microcomputer peripheral device called a *programmable timer*. This device connects directly to the microcomputer bus and may be configured (by software) to perform the timing measurements required. When the programmable timer and microcomputer are connected for use as a laboratory timer, there is a clear division of labor: the programmable timer performs the time measurements, and the microcomputer records the results.

Figure 1 is a programming model of a common programmable timer. In addition to its connections to the microcomputer bus, the timer also has a gate input $\overline{G}$, an external clock input $\overline{C}$, and an output O. Inside the timer are three addressable registers:

- An 8-bit, write-only *control register* that is used to establish the timer's operating mode, in much the same way as a control register configures the operation of a common PIA (peripheral interface adapter);
- A 16-bit write-only *latch*. Its contents are divided into two 8-bit bytes, called M, for the more-significant (or high-order) byte, and L, for the less-significant (or low-order) byte. The latch's contents are preset to hexadecimal FFFF on system power-up or $\overline{\text{RESET}}$, and they may be changed at any time by the program running in the microcomputer;
- A 16-bit write-only *counting register*. A momentary logic-0 level at the timer's gate input causes this register to be loaded with bytes M and L from the latch. The counting register then decrements on each cycle of a specified timing signal. Further operating details are dictated by the timer's operating mode.

Text continued on page 114

Circle 159 on Inquiry card. →



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Completely Programmable. Smartmodem can be controlled using *any* programming language. Over 30 different commands can be written into your programs or entered directly from your keyboard.

Smartmodem also includes several switch-selectable features that let you tailor performance to your exact needs. You can "set it and forget it" for the ultimate in convenience.

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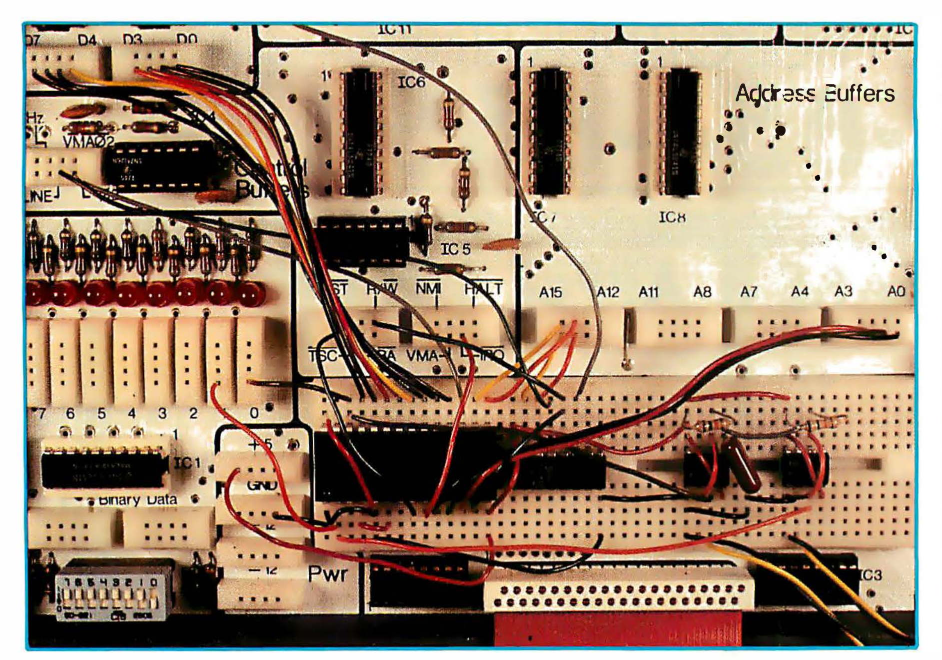


Photo 1: *Heath ET-3400 microcomputer trainer wired for use as a two-channel, data-logging, millisecond timer. The picture shows all circuit components except the phototransistors, which are connected to the type-555 integrated circuits (used as input comparators) via the two yellow-black twisted pairs of wires at the lower right.*

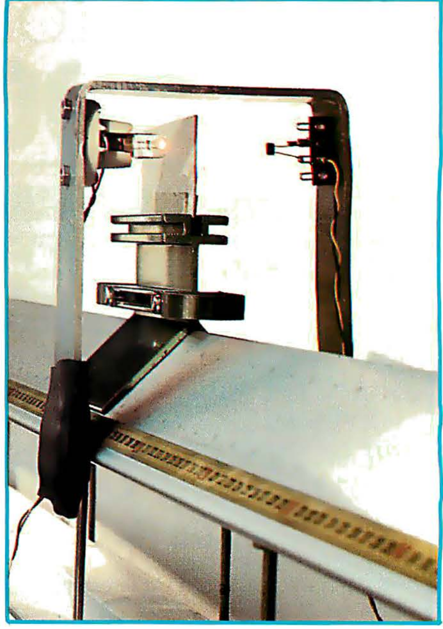


Photo 2: *Lamp and phototransistor attached to one end of the air track. For best timing resolution, the lamp is mounted so that its filament is vertical.*

Text continued from page 110:

The programmable timer is a versatile device with several operating modes, two of which are useful for elapsed-time measurements:

- *Pulse-width-comparison mode,* in which the timer measures the length of time its gate input is held at logic 0;
- *Frequency-comparison mode,* in which the timer measures the time between two successive logic 0s at its gate input.

These two types of time measurement are illustrated in figure 2.

Time-Interval Measurement

Each elapsed-time measurement consists of six steps. The first three steps are performed by the programmable timer, and the last three are performed by the microcomputer.

The following three measurements are those performed in sequence by a timer programmed for operation in the *pulse-width-comparison mode* (by storing hexadecimal 58 in its control register):

1. The timer's gate input, normally at logic 1, is pulled to logic 0 at the beginning of the timed event. This loads the timer's counting register with bytes M and L from the latch.
2. The counting register then decrements on each cycle of a timing signal applied to the timer's external-clock input and continues to do so while the gate input is held at logic 0.
3. The gate input is driven back to logic 1 at the end of the timed event. If this occurs before the counting register reaches zero, the count stops, and the timer generates a program interrupt by pulling the microcomputer's active-low $\overline{\text{IRQ}}$ (interrupt-request) line to logic 0.

The three measurement steps performed by a timer programmed for operation in the *frequency-comparison mode* (by storing hexadecimal 48 in its control register) are as follows:

1. The timer's gate input, normally at

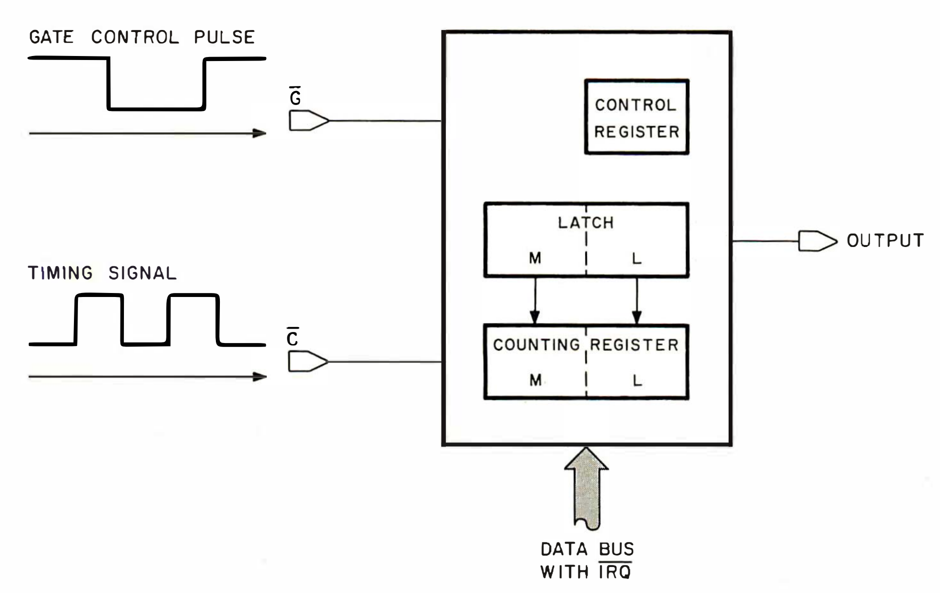


Figure 1: *Model of the programmable timer, showing gate input $\overline{G}$, external-clock input $\overline{C}$, output O, the connection to the microcomputer bus, and the addressable registers. The arrows pointing from the latch to the counting register indicate the data transfer that takes place at the beginning of each count. Output O is not used in either the pulse-width-comparison or frequency-comparison modes of operation.*

logic 1, is *momentarily* pulled to logic 0 at the beginning of the timed event. This loads the timer's counting register with bytes M and L from the latch.

2. The counting register then decrements on each cycle of a timing signal applied to the timer's external-clock input and continues to do so, even though the gate input returns to logic 1.

3. The gate input is again momentarily pulled to logic 0 at the end of the timed event. If this occurs before the counting register reaches zero, the count stops, and the timer generates a program interrupt by pulling the microcomputer's $\overline{IRQ}$ line to logic 0.

For either operating mode, the timer ends its three-step sequence by signaling the microcomputer over its $\overline{IRQ}$ line. The microcomputer's task begins when it receives the interrupt signal indicating that the timer has finished a count. The microcomputer then takes over the last three steps and:

4. Reads the timer's counting register.
5. Transforms the count into a useful measurement of elapsed time.
6. Saves the result.

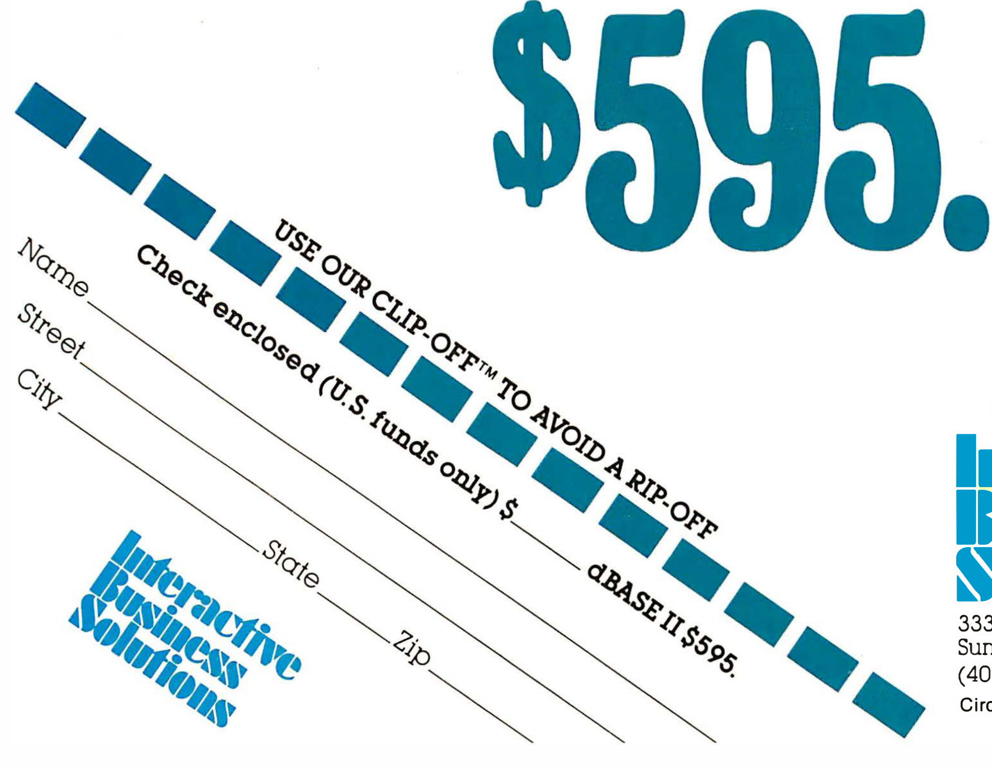
We will now examine all of these

Text continued on page 118



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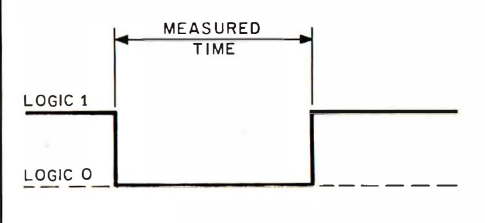
measurement steps in detail.

Step 1 is initiated by the gating device (eg: a photocell) that is connected to the programmable timer's gate input. Figure 3 shows two circuits for coupling phototransistors to the timer.

In figure 3a, the phototransistor is illuminated normally, and the programmable timer's gate input is held at logic 1. An object passing in front of the phototransistor will cause the programmable timer's gate input to be pulled to logic 0 and held there for as long as the light is blocked. If the timer is operating in the pulse-width-comparison mode, it will measure the length of time the light is blocked. If it is operating in the frequency-comparison mode, the timer will measure the elapsed time from the first extinction of the light to the second.

In figure 3b, both phototransistors are normally illuminated, and the timer's gate input is held at logic 1. An object passing in front of either phototransistor produces a momentary logic 0 at the programmable timer's gate input. A second momentary logic 0 occurs as the object passes in front of the second phototransistor. If operated in the frequency-comparison mode, the timer will measure the time from the first extinction of the light (at one phototransistor) to the second (at the other phototransistor).

Text continued on page 122



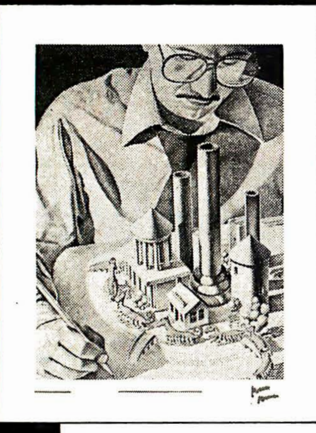
FREQUENCY COMPARISON
MEASURED TIME
LOGIC 1
LOGIC 0

Figure 2: *The time intervals measured by the programmable timer for the pulse-width and frequency-comparison modes.*

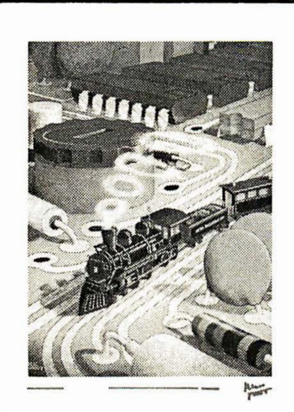
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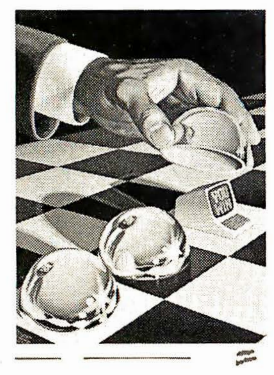
#1



#5



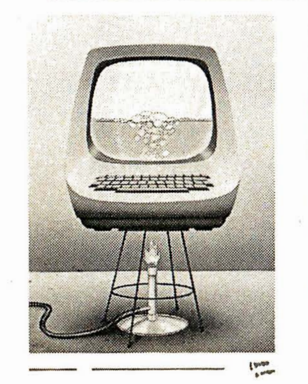
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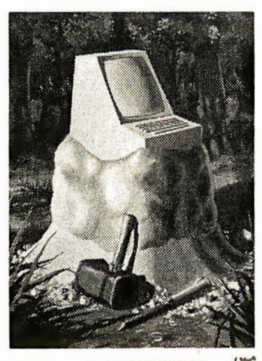
#6



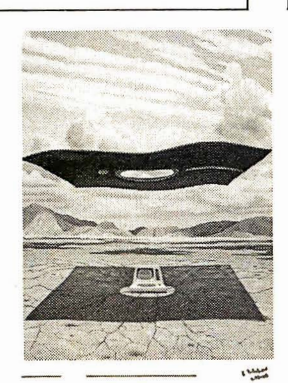
#3



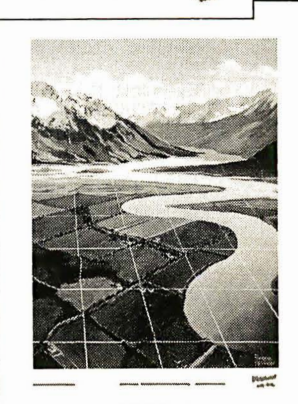
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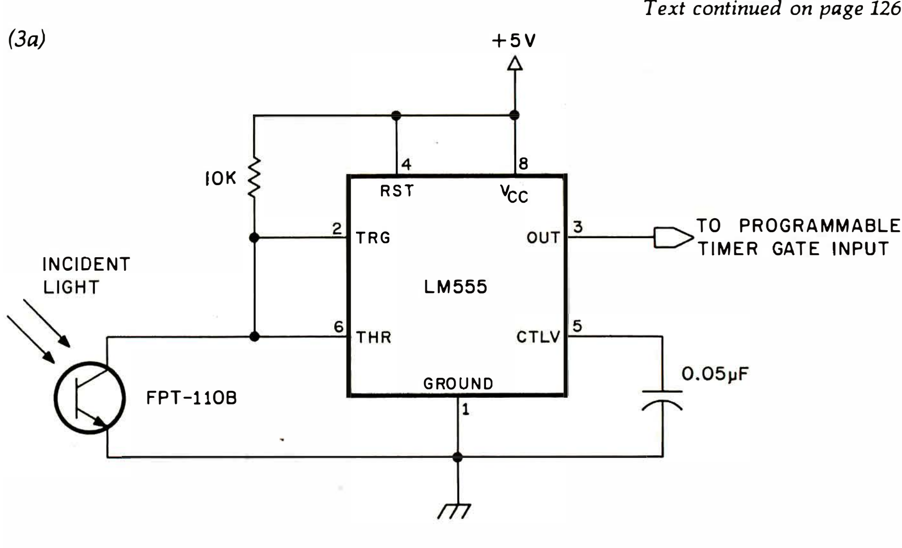
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Text continued from page 118:

Step 2 states that the counter decrements on each cycle of an external timing signal. The period of this timing signal therefore becomes the *limit of resolution* of any time measurement. My applications required elapsed-time measurements that were accurate to the nearest ms (millisecond). This resolution was achieved by applying a 1 kHz timing signal to the timer's external-clock input. (Later I will describe how this timing signal is produced by using another programmable timer to scale the microprocessor's clock frequency.)

Step 3 says that the count stops, and the microcomputer is signaled, if the timed event ends before the counting register decrements to zero. Recall that the timer's latch is preset to unsigned 65,535 (hexadecimal

Text continued on page 126



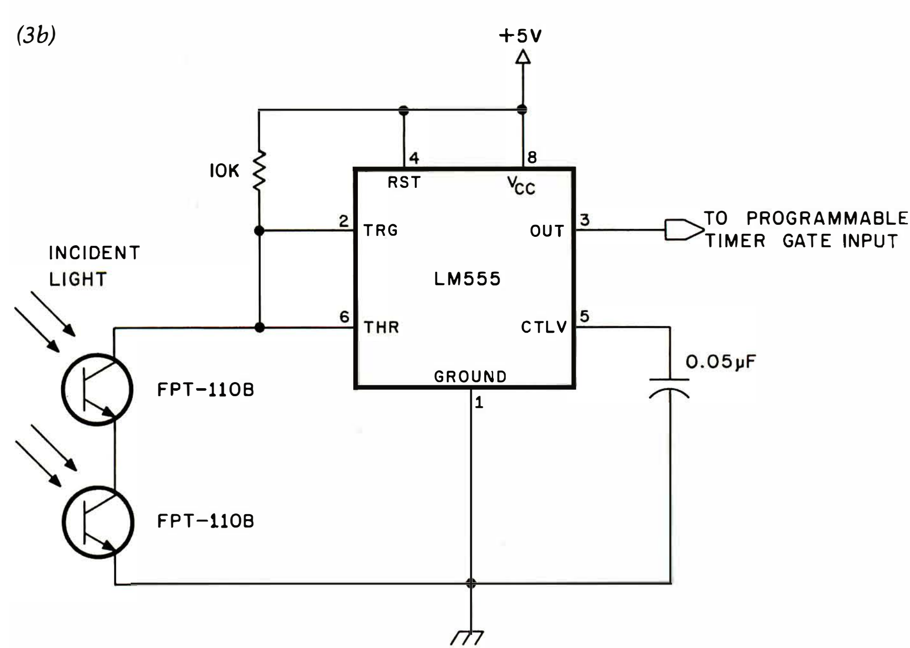


Figure 3: *Two circuits for connecting phototransistors to programmable-timer gate inputs. Figure 3a shows control of the timer gate by a single phototransistor; figure 3b shows control by two phototransistors.*

These type-555 integrated circuits are **not** *used as timers; instead, they serve as inverting comparators. A 555 component connected in this manner has an input hysteresis in excess of 1.6 V, twice that of a type-7413 Schmitt trigger.*

The 10 k-ohm resistor is chosen to saturate the phototransistor when illuminated, and hold it near its cutoff point when the light is blocked. The 10 k-ohm resistance is optimal for a 1 W incandescent bulb located 5 cm (approximately 2 inches) in front of the phototransistor. Other setups may require a different resistor.

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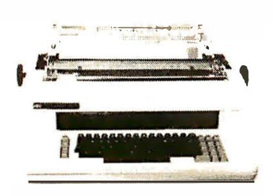
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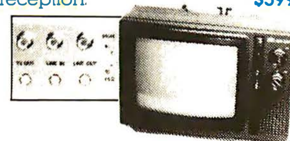
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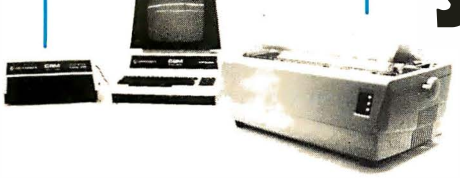
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Text continued from page 122:

Listing 1: *Interrupt-service routine for reading a programmable timer's counting register, converting the number to a decimal elapsed time and saving the result.*

Label	Op Code	Comments
	LDA A M	Read the timer's counting register and clear the timer's interrupt request.
	LDA B L	
	LDX POINT	Fetch the pointer.
	CPX #LAST+3	Are all memory locations loaded?
	BEQ DONE	Branch if all are loaded.
	COM A	Complement the count to get the hexadecimal elapsed time.
	COM B	
	STA A 1,X	Save the hexadecimal elapsed time in this memory location.
	STA B 2,X	
	LDA A #$80	Set bit 7 to show that this memory location has been loaded.
	STA A 0,X	
	BSR BD	Perform a subroutine that converts the 2-byte hexadecimal number in 1,X and 2,X to a 2½-byte BCD number in 0,X, 1,X and 2,X.
	INX	
	INX	Advance the pointer to the next 3-byte memory location.
	INX	
	STX POINT	Save the new pointer value.
DONE	RTI	

FFFF) on system power-up or $\overline{\text{RESET}}$. Unless changed by the program, this value is automatically loaded into the counting register at the beginning of each timed event. The counting register cannot decrement more than this number of counts. A 1 kHz timing signal will therefore permit a maximum time measurement of 65,535 ms, or 65.535 seconds.

Step 4 begins the program's interrupt-service routine by reading the timer's counting register. Aside from fetching the counting register's contents, this step has another purpose: the read operation causes the programmable timer to release the microcomputer's $\overline{\text{IRQ}}$ line. This is important, because it is the *only* way the timer's interrupt request can be cleared.

Step 5 indicates a need for transforming the count. The quantity read from the timer's counting register (for a 1 kHz timing signal) is the *hexadecimal* number of milliseconds *remaining* until the counter decrements to zero. To be useful, this number should be transformed into the *decimal* number of milliseconds *elapsed* during the timed event. This transformation is a two-step process:

5a. Convert the hexadecimal milliseconds remaining to hexadecimal milliseconds elapsed during the timed event.
5b. Convert the hexadecimal milliseconds to decimal milliseconds.

Step 5a is easily performed. If the timer's counting register is set to hexadecimal FFFF at the beginning of the count, the hexadecimal number of elapsed milliseconds is equal to FFFF—n_t, where n_t is the remainder read from the counting register at the end of the timed event. But, since FFFF—n_t is just the one's complement of n_t, step 5a simply requires taking the one's complement of the number read from the counting register.

Step 5b is a hexadecimal-to-decimal conversion routine. Any appropriate routine may be used here. Listing 2 contains a fully documented demonstration program that includes a suitable hexadecimal-to-decimal conversion routine.

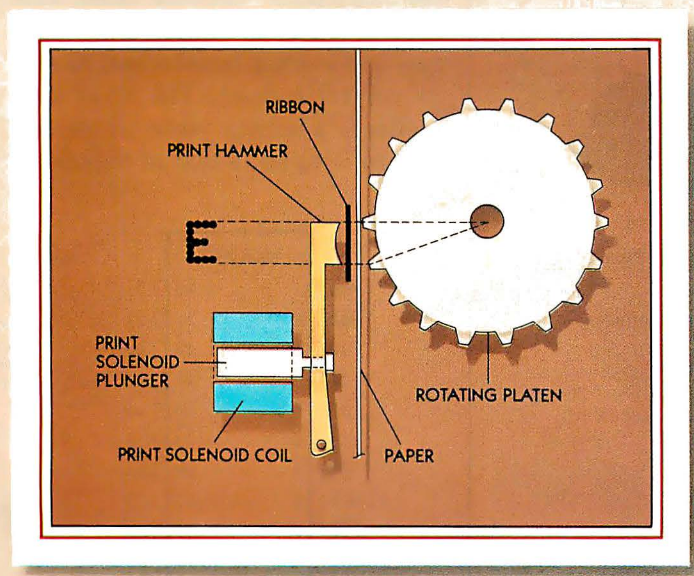
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Step 6 states that the microcomputer must save the result (ie: save the transformed time measurement). If several time measurements are made in rapid succession, the computer must log these results in a manner that permits easy access.

Successive time measurements are saved in successive 3-byte memory locations in a reserved memory block. Why 3 bytes? Although the binary number read from the timer's counting register is contained in only 2 bytes, that number converted to decimal form may require five BCD (binary-coded decimal) digits (for a maximum elapsed time of 65,535 ms). Stored in "packed" BCD form, such a number occupies 2½ bytes of memory. I allow 3 bytes, because I use bit 7 of the most-significant byte as a flag that is set when the memory location has been loaded with a measured time.

Listing 1 is a set of MC6800 instructions for accomplishing steps 4, 5, and 6 of the measurement sequence. This interrupt-service routine reads the timer's counting register, transforms the count into a decimal-radix elapsed time, and saves the result.

Lines 3, 4, and 5 of the listing merit further explanation. POINT always contains the address of the next memory location in which a time measurement will be stored. Line 3 loads the index register with this pointer. Line 4 examines the pointer to see if the allocated memory space has been exceeded. If it has, line 5 causes a skip of the remaining steps.

Notice that the testing of the pointer does not occur until *after* the timer's counting register has been read (lines 1 and 2). The counting register must *always* be read, whether or not the results are to be saved. Otherwise the timer's interrupt request will not be cleared.

A Programmable-Timer Module

Thus far, I have described how a single programmable timer may be used with a microcomputer to measure and log elapsed times of successive events. I now wish to show how a particular commercial device, the Motorola MC6840 programmable-timer module, may be used in the design of a two-channel event timer.

Figure 4 is a pin-assignment diagram for the MC6840. This integrated circuit contains three independent programmable timers, each with gate input, external-clock input, and output. There are ten addressable registers. Nine of these are the control registers, latches, and counting registers for the three timers; the tenth is a status register containing interrupt flags. (Details of register selection for the MC6840 were described in my earlier article, "A Computer-Controlled Light Dimmer," January 1980 BYTE, page 56.)

A two-channel event timer requires the use of one programmable timer for each channel. If timer 1 is assigned to channel 1 and timer 2 is assigned to channel 2, then timer 3 may be used to scale the microprocessor clock frequency to provide the timing signal required by timers 1 and 2.

To operate as a frequency scaler, timer 3 must be configured for use in the *continuous operating mode*. This is achieved by grounding the timer's gate and loading hexadecimal 82 into its control register. The timer then produces a square wave whose frequency is equal to that of the micro-

MC6840

V_{SS}	1	28	$\overline{C1}$
$\overline{G2}$	2	27	O1
O2	3	26	$\overline{G1}$
$\overline{C2}$	4	25	D0
$\overline{G3}$	5	24	D1
O3	6	23	D2
$\overline{C3}$	7	22	D3
$\overline{RESET}$	8	21	D4
$\overline{IRQ}$	9	20	D5
RS0	10	19	D6
RS1	11	18	D7
RS2	12	17	ENABLE
R/$\overline{W}$	13	16	CS1
V_{CC}	14	15	$\overline{CS0}$

Figure 4: *Pin-assignment diagram for the Motorola MC6840 programmable-timer module.*

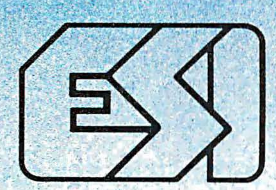
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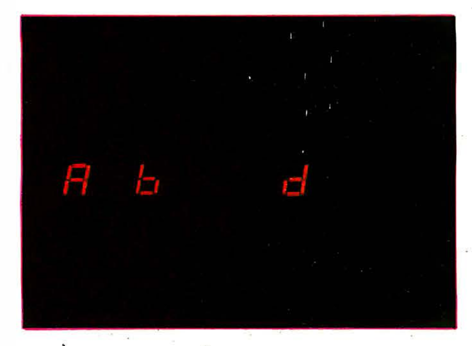


Photo 3: *The trainer's six-character LED display is used to indicate which memory locations have been loaded with elapsed-time measurements. This is how the display appears after time measurements have been logged in memory locations A and B (for phototransistor 1) and location D (for phototransistor 2).*

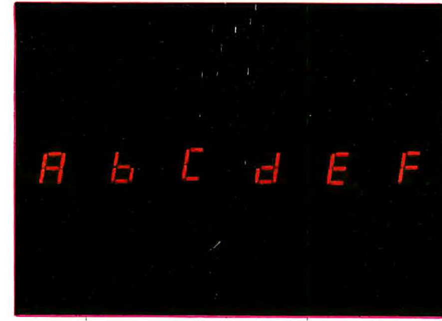


Photo 4: *The trainer's six-character LED display after elapsed-time measurements have been logged in all six memory locations, A thru F.*



Photo 5: *A measured time is read by pressing a letter key on the trainer's hexadecimal keyboard. This is the display's appearance when the A key is pressed to read out the elapsed-time measurement (here 1.581 seconds) stored at memory location A.*

processor clock divided by $2(n+1)$, where n is the 16-bit number stored in the timer's latch. (For example, given a microprocessor clock frequency of 1 MHz, storing decimal 499 [hexadecimal 01F3] in the timer's latch will cause the timer to generate a 1 kHz square wave.) Figure 5 shows the appropriate input and output connections for timer 3.

Polling the Timers

When timers 1 and 2 are operated in either the pulse-width-comparison mode or the frequency-comparison mode, either timer may signal the completion of a count by pulling the microcomputer's $\overline{\text{IRQ}}$ line low. The microcomputer, with the aid of the MC6840's status register, then *polls* the timers to find which produced the interrupt.

The status register is an 8-bit, read-only register containing interrupt flags. It shares an address with control register 2 (CR2). The R/$\overline{\text{W}}$ line selects whether CR2 is written or the status register is read. Individual bits of the status register are assigned as shown in table 1.

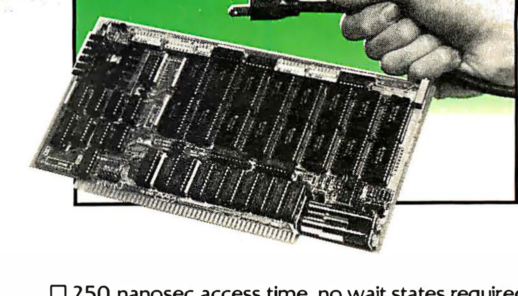
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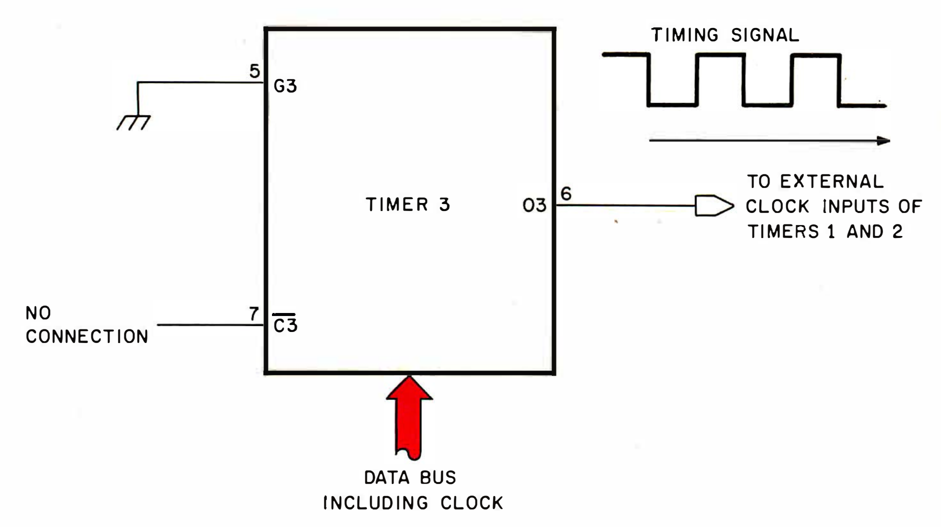


Figure 5: *Connection of the MC6840's timer-section 3 for use as a frequency scaler. The microprocessor's clock frequency is divided by 2(n+1) to provide a timing signal to timers 1 and 2.*

Bit 0:	Timer 1 individual interrupt flag.
Bit 1:	Timer 2 individual interrupt flag.
Bit 2:	Timer 3 individual interrupt flag.
Bit 3:	Composite interrupt flag.
Bits 4 thru 7:	All read as zero.

Table 1: *Assignment of bits in the status register of the Motorola MC6840 programmable-timer module.*

comparison mode or the frequency-comparison mode, then its individual interrupt flag is *set* whenever the timer completes a time measurement before its counting register decrements to zero. The flag is automatically *cleared* when the status register *and* the timer's counting register are read (in that order).

The composite interrupt flag is the logical OR of the individual interrupt flags. For the operating modes that I have selected for the three timers, the composite interrupt flag will be clear only if both the timer 1 and timer 2 flags are clear. (Timer 3's configuration as a scaler prevents it from affecting the composite interrupt flag.)

The MC6840 pulls the microcomputer's $\overline{\text{IRQ}}$ line low when the composite interrupt flag is set, which, for these operating modes, is whenever the timer 1 or timer 2 individual interrupt flags are set. The $\overline{\text{IRQ}}$ line is released only when both timer 1 and timer 2 individual interrupt flags are cleared.

Upon receipt of the interrupt request ($\overline{\text{IRQ}}$ line pulled low), the microcomputer performs an interrupt-service routine that examines the status register to find which timer's interrupt flag is set. With that deter-

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mined, it then performs the remaining steps (4, 5, and 6) of the program's data-acquisition routine.

Building the Timing System

I have just described the system-independent design details of a two-channel, data-logging, millisecond timer using a Motorola MC6840 programmable-timer module; I will now show you how to implement this design on a Heathkit ET-3400 microprocessor trainer.

We have seen that a millisecond-resolution timer requires a 1 kHz external timing signal, and we have seen how this external timing signal can be scaled from a 1 MHz microprocessor clock. The implementation assumes the use of an ET-3400 trainer with a 1 MHz crystal-controlled clock. This 1 MHz clock is a feature of all trainers modified for use with the Heathkit ETA-3400 expansion accessory.

The demonstration program (see listing 2) assumes the availability of 340 bytes of memory for program storage. This exceeds memory available in the trainer alone, unless some page-zero memory is used for this purpose. Addition of the ETA-3400 expansion accessory easily provides the additional program-storage space required.

Figure 6 is a complete circuit diagram for the two-channel, millisecond timer. The entire circuit (except for the phototransistors) may be wired on the trainer's built-in breadboard socket (see photo 1).

Figure 6 contains one system-dependent feature that requires explanation. The ET-3400 trainer uses a bidirectional buffer to couple its data bus to outside devices. Normally set in the write (output) state, this buffer is placed in the read (input) state by pulling the trainer's $\overline{RE}$ (read enable) line low. The 7445 binary-to-decimal decoder in figure 6 provides the address decoding needed to do this each time the trainer reads the MC6840 registers.

Text continued on page 144

Listing 2: *Complete timer-demonstration program for using the Motorola MC6840 with Heath's ET-3400 microcomputer trainer. The program (written in 6800 assembly language) assumes the availabilty of 340 bytes of memory for program storage, so an ETA-3400 memory-expansion module must be installed.*

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      0000                ORG     0

      0000 0003  T11      RMB     3         / ELAPSED TIME A
      0003 0003  T12      RMB     3         / ELAPSED TIME B
      0006 0003  T13      RMB     3         / ELAPSED TIME C

      0009 0003  T21      RMB     3         / ELAPSED TIME D
      000C 0003  T22      RMB     3         / ELAPSED TIME E
      000F 0003  T23      RMB     3         / ELAPSED TIME F

      0012 0001  TEMP1    RMB     1
      0013 0001  TEMP2    RMB     1

      0014 0002  POINT1   RMB     2         / POINTER FOR TIMER #1
      0016 0002  POINT2   RMB     2         / POINTER FOR TIMER #2

           00F7  UIRQ     EQU     $00F7     / MONITOR VECTORS HERE ON IRQ

                 * ADDRESSES IN PROGRAMMABLE TIMING MODULE

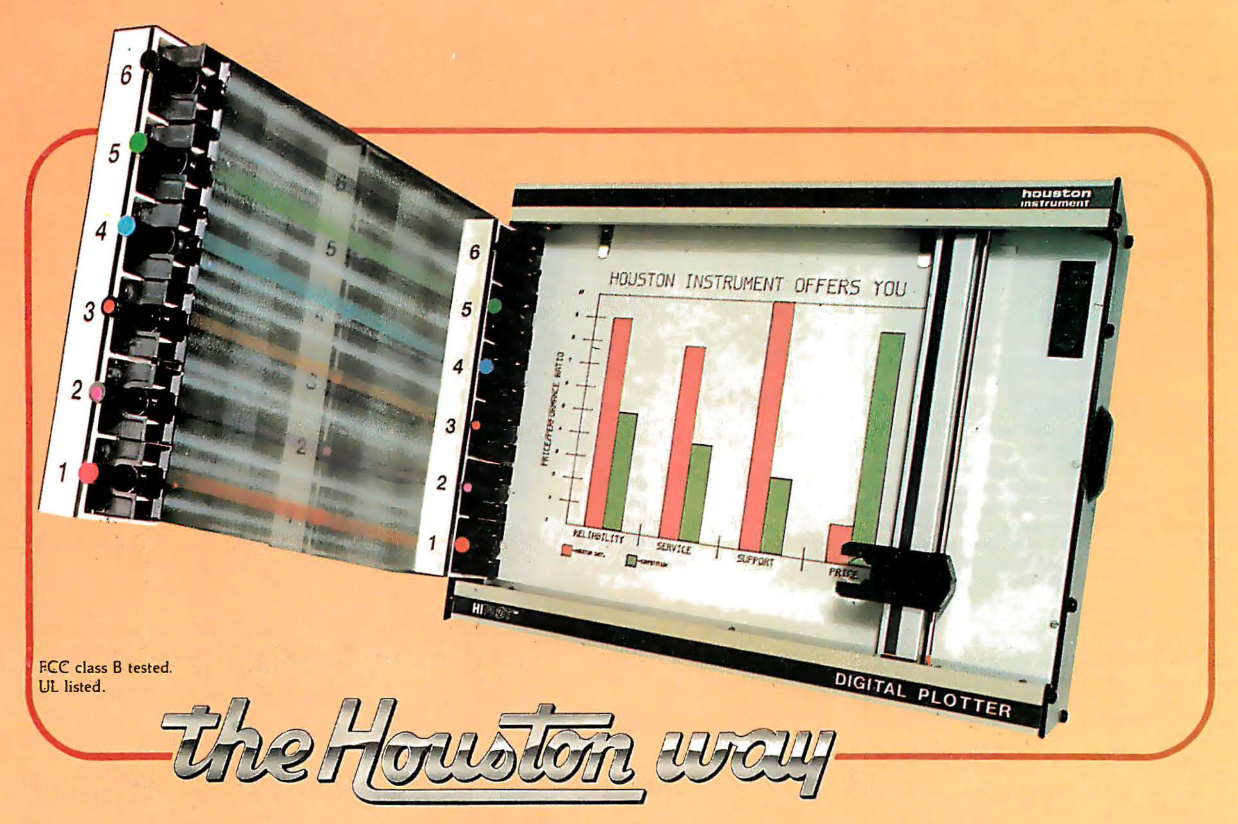
           8000  CR1      EQU     $8000
           8001  CR2      EQU     CR1+1
           8000  CR3      EQU     CR1

           8001  STATUS   EQU     CR2       / CONTAINS INTERRUPT FLAGS

           8002  M1       EQU     CR1+2
```

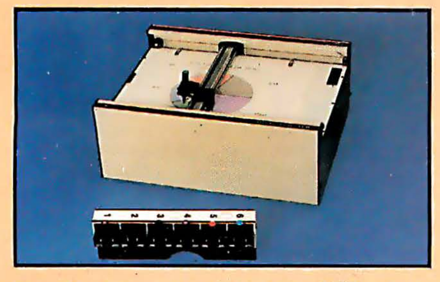
Listing 2 continued on page 136

New from HIPLØT™
6-pen plotting for as little as $1480*.



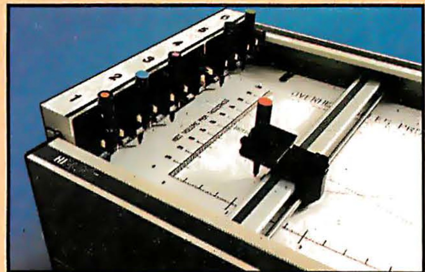
And you can retrofit your present single pen HIPLØT for only $395.

The new HIPLØT DMP Series 6-pen option makes high performance multi-pen plotting affordable. It's available on all six models in the HIPLØT family so you can enjoy the advantages of multi-colored plots on surfaces of 8½" × 11" (DIN A4) or 11" × 17" (DIN A3). Of course, you also get the standard HIPLØT range of capabilities such as intelligence, controls, interfaces and resolutions. There's a model for virtually every plotting application.



Big Performance in a Small Plotter

Since it's introduction, the HIPLØT DMP Series has been recognized as the innovative plotter line which made low-cost, high performance digital plotting a reality.



Now, with our new 6-pen option, there's an exciting new dimension in the DMP Series' versatility. Imagine two standard models with RS-232-C and parallel interfaces, four intelligent models with RS-232-C or Centronics® compatible interfaces, a choice of controls, resolutions, and pen speeds. Add to this the ability to plot with 6-pens on paper, vellum or mylar (ideal for overhead projectors) and you have the ultimate plotter price/performance combination — the perfect choice for the user or OEM.

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Circle 165 for literature
Circle 166 to have representative call

Listing 2 continued:

```
      8003          L1      EQU     CR1+3

      8004          M2      EQU     CR1+4
      8005          L2      EQU     CR1+5

      8006          M3      EQU     CR1+6
      8007          L3      EQU     CR1+7


                    * THESE ET-3400 MONITOR SUBROUTINES ARE USED.

      FCBC          REDIS   EQU     $FCBC      / RESETS DISPLAY TO 1ST LED
      FE28          OUTHEX  EQU     $FE28      / DISPLAYS HEX DIGIT FROM 'A'
      FE3A          OUTCH   EQU     $FE3A      / DISPLAYS CODED CHARACTER
      FDBB          ENCODE  EQU     $FDBB      / RETURNS KEY'S HEX VALUE
      FD7B          DSPLAY  EQU     $FD7B      / DISPLAYS HEX DIGIT STRING
                    * THESE STEPS INITIALIZE TIMERS 1 AND 2 FOR USE IN
                    * THE PULSE WIDTH COMPARISON MODE IN WHICH AN IRQ
                    * INTERRUPT IS GENERATED AT THE END OF EACH TIMED
                    * INTERVAL.  TIMER 3 IS USED TO SCALE THE 1MHZ
                    * MICROPROCESSOR CLOCK TO PROVIDE A 1KHZ EXTERNAL
                    * CLOCK FREQUENCY TO TIMERS 1 AND 2.

0100                        ORG     $100       / START FROM THIS ADDRESS.

0100 0F             START   SEI                / MASK IRQ INTERRUPT

0101 CE 01F3                LDX     #499       / SCALING FACTOR = 2(499+1)
0104 FF 8006                STX     M3         / INITIALIZE TIMER #3

0107 86 82                  LDA A   #$82       / CONFIGURE TIMER #3 FOR USE
0109 B7 8000                STA A   CR3        / AS A SCALAR

010C 86 59                  LDA A   #$59       / CONFIGURE TIMERS #1 AND #2
010E B7 8001                STA A   CR2        / FOR PULSE WIDTH COMP MODE;
0111 B7 8000                STA A   CR1        / INTERNALLY RESET ALL TIMERS

0114 4A                     DEC A              / CLEAR INTERNAL RESET BIT
0115 B7 8000                STA A   CR1        / TO ENABLE ALL TIMERS


                    * ON IRQ, THE ET-3400 VECTORS TO LOCATION
                    * #UIRQ, WHERE IT MUST FIND A JUMP INSTRUCTION
                    * AND A VECTOR TO TRANSFER TO THE PROGRAM'S
                    * IRQ SERVICE ROUTINE AT LOCATION #POLL.

0118 86 7E                  LDA A   #$7E       / LDA A WITH JUMP COMMAND
011A 97 F7                  STA A   UIRQ       / STORE JUMP COMMAND AT UIRQ

011C CE 01BE                LDX     #POLL      / JUMP TO THIS LOCATION
011F DF F8                  STX     UIRQ+1     / STORE #POLL AT UIRQ VECTOR

0121 0E                     CLI                / CLEAR IRQ INTERRUPT MASK


                    * INITIALIZE THE MEMORY LOCATION POINTERS

0122 CE 0009                LDX     #T21
0125 DF 16                  STX     POINT2

0127 CE 0000                LDX     #T11
012A DF 14                  STX     POINT1
                    * CLEAR ALL MEMORY LOCATIONS

012C 6F 00          CLEAR   CLR     0,X        / CLEAR THIS BYTE
012E 08                     INX                / POINT TO THE NEXT BYTE
012F 8C 0012                CPX     #T23+3     / DONE YET?
0132 26 F8                  BNE     CLEAR      / GO CLEAR THE NEXT BYTE


                    * MAIN PROGRAM LOOP

0134 8D 11          RUN     BSR     SHOW       /SHOW LETTERS OF LOGGED TIMES
0136 8D 30                  BSR     KEY        /RETURNS DEBOUNCED KEY IN 'A'
0138 24 FA                  BCC     RUN        / GO BACK IF NO KEY PRESSED

013A 4D                     TST A
013B 27 C3                  BEQ     START      / GO TO START ON '0' KEY

013D 8D 35                  BSR     SETX       / POINT TO KEYED LOCATION
013F 24 F3                  BCC     RUN        / BRANCH IF KEYS 1-9 PUSHED

0141 8D 44                  BSR     READOU     / SHOW KEYED ELAPSED TIME
0143 8D 6E                  BSR     RELEAS     / WAIT FOR KEY RELEASE
0145 20 ED                  BRA     RUN        / RETURN TO SHOW LETTERS
```

Listing 2 continued on page 138

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Listing 2 continued:

```
                   * THIS ROUTINE DISPLAYS LETTERS FOR MEMORY
                   * LOCATIONS IN WHICH ELAPSED TIMES ARE LOGGED.

0147 CE 0000 SHOW   LDX     #T11      / POINT TO THE FIRST LOCATION
014A 86 0A          LDA A   #$0A      / INITIALIZE DISPLAY LETTER
014C BD FCBC        JSR     REDIS     / INITIALIZE DISPLAY POINTER

014F E6 00   SHOW1  LDA B   0,X       / TEST BIT7 FOR TIME LOGGED
0151 2A 05          BPL     SHOW2     / BRANCH IF NO TIME LOGGED

0153 BD FE28        JSR     OUTHEX    / SHOW THE LETTER FROM 'A'
0156 20 06          BRA     SHOW3

0158 36      SHOW2  PSH A             / SAVE THE LETTER FROM 'A'
0159 4F             CLR A             / PREPARE TO SHOW A BLANK
015A BD FE3A        JSR     OUTCH     / SHOW A BLANK HERE
015D 32             PUL A             / RESTORE KEYED LETTER TO 'A'

015E 4C      SHOW3  INC A             / INC 'A' TO THE NEXT LETTER
015F 08             INX
0160 08             INX               / ADVANCE THE POINTER TO THE
0161 08             INX               / NEXT 3-BYTE MEMORY LOCATION
0162 8C 0012        CPX     #T23+3    / DONE YET?
0165 26 E8          BNE     SHOW1     / EXAMINE THE NEXT LOCATION

0167 39             RTS
                   * THIS ROUTINE DEBOUNCES A PRESSED KEY AND RETURNS
                   * ITS HEX VALUE IN ACC A.  THE ROUTINE ALSO
                   * RETURNS CARRY SET FOR KEY PRESSED, CARRY
                   * CLEAR FOR NO KEY PRESSED.

0168 C6 14   KEY    LDA B   #20       / INITIALIZE DELAY COUNTER

016A BD FDBB KEY1   JSR     ENCODE    / RETURNS KEY VALUE IN 'A'
016D 24 04          BCC     KEY2      / BRANCH IF NO KEY DOWN

016F 5A             DEC B             / DECREMENT THE DELAY TIME
0170 26 F8          BNE     KEY1      / GO BACK, IF DELAY NOT DONE

0172 0D             SEC               / SET CARRY IF KEY DOWN

0173 39      KEY2   RTS


                   * THIS ROUTINE USES THE HEX VALUE (IN ACC A)
                   * OF THE KEY PRESSED TO POINT X TO THE PROPER
                   * MEMORY LOCATION.  THE ROUTINE RETURNS CARRY
                   * SET IF KEYS A-F PRESSED, CARRY CLEAR
                   * IF KEYS 1-9 ARE PRESSED.

0174 CE 0000 SETX   LDX     #T11      / POINT X TO FIRST LOCATION
0177 C6 0A          LDA B   #$0A      / INITIATE 'B'

0179 11      SETX1  CBA               / DOES 'B' EQUAL KEY VALUE?
017A 27 09          BEQ     SETX2     / BRANCH IF EQUAL

017C 0C             CLC               / CLEAR THE A-F KEY FLAG
017D 2B 07          BMI     SETX3     / RTS IF 'B' > KEY VALUE

017F 08             INX
0180 08             INX               / ADVANCE THE POINTER TO THE
0181 08             INX               / NEXT 3-BYTE MEMORY LOCATION
0182 5C             INC B             / INCREMENT 'B' AND
0183 20 F4          BRA     SETX1     / GO COMPARE AGAIN

0185 0D      SETX2  SEC               / SET THE A-F KEY FLAG

0186 39      SETX3  RTS
                   * READOUT ROUTINE: DISPLAYS KEYED LETTER AND
                   * ELAPSED TIME STORED IN THIS LOCATION.  THE
                   * DISPLAY IS IN SECONDS WITH RESOLUTION TO
                   * 1 MILLISECOND.  LEADING ZEROS TO THE LEFT
                   * OF THE DECIMAL POINT ARE SUPPRESSED.

0187 E6 00   READOU LDA B   0,X       / FETCH BIT 7
0189 2A 27          BPL     READ2     / BRANCH IF NO TIME LOGGED

018B 36             PSH A             / SAVE KEY VALUE (FROM 'A')
018C BD FCBC        JSR     REDIS     / INITIALIZE DISPLAY POINTER
018F C6 03          LDA B   #03       / TO DISPLAY 3 BYTES
0191 BD FD7B        JSR     DSPLAY    / DISPLAY THIS ELAPSED TIME

0194 BD FCBC        JSR     REDIS     / RESET THE DISPLAY POINTER
0197 32             PUL A             / RESTORE KEY VALUE TO 'A'
```

Listing 2 continued on page 140

Listing 2 continued:

```
0198 BD FE28          JSR    OUTHEX     / SHOW KEY PUSHED (FROM 'A')

019B A6 00            LDA A  0,X        / GET 1ST DIGIT (AND BIT 7)
019D 84 0F            AND A  #$0F       / MASK TO FIRST DIGIT
019F 26 0C            BNE    READ1      / BRANCH IF NOT LEADING ZERO

01A1 BD FE3A          JSR    OUTCH      / BLANK 2ND 7-SEGMENT LED

01A4 A6 01            LDA A  1,X        / GET 2ND (AND 3RD) DIGIT
01A6 84 F0            AND A  #$F0       / MASK TO 2ND DIGIT
01A8 26 03            BNE    READ1      / BRANCH IF NOT ALSO ZERO

01AA BD FE3A          JSR    OUTCH      / BLANK 3RD 7-SEGMENT LED

01AD 86 01     READ1  LDA A  #$01
01AF B7 C147          STA A  $C147      / LIGHT 3RD DECIMAL POINT

01B2 39        READ2  RTS


               * THIS ROUTINE WAITS FOR A KEY RELEASE

01B3 C6 14     RELEAS LDA B  #20        / INITIALIZE DELAY COUNTER

01B5 BD FDBB   REL1   JSR    ENCODE     / GET KEY RELEASE CONDITION
01B8 25 F9            BCS    RELEAS     / KEEP TRYING UNTIL RELEASE

01BA 5A               DEC B             / DECREMENT THE DELAY TIME
01BB 26 F8            BNE    REL1       / GO BACK IF DELAY NOT DONE

01BD 39               RTS
               * THIS BEGINS THE IRQ SERVICE ROUTINE THAT
               * READS AND LOGS THE MEASURED TIMES.

01BE B6 8001   POLL   LDA A  STATUS     / GET THE INTERRUPT FLAGS

01C1 44        POLL1  LSR A             / SHIFT TIMER1 FLAG INTO 'C'
01C2 36               PSH A             / SAVE THE TIMER2 FLAG
01C3 24 11            BCC    POLL2      / BRANCH IF NO TIMER1 FLAG

01C5 B6 8002          LDA A  M1         / READ THE TIMER1 COUNT AND
01C8 F6 8003          LDA B  L1         / CLEAR THE TIMER1 FLAG

01CB DE 14            LDX    POINT1     / POINT TO THE T1X LOCATION
01CD 8C 0009          CPX    #T13+3     / TIMER1 MEMORY BLOCK FULL?
01D0 27 04            BEQ    POLL2      / BRANCH IF FULL

01D2 8D 18            BSR    LOG        / LOG COUNT, ADV POINTER
01D4 DF 14            STX    POINT1     / SAVE THE NEW POINTER

01D6 32        POLL2  PUL A             / RESTORE THE TIMER2 FLAG
01D7 44               LSR A             / SHIFT TIMER2 FLAG INTO 'C'
01D8 24 11            BCC    DONE       / BRANCH IF NO TIMER2 FLAG

01DA B6 8004          LDA A  M2         / READ THE TIMER2 COUNT AND
01DD F6 8005          LDA B  L2         / CLEAR THE TIMER2 FLAG

01E0 DE 16            LDX    POINT2     / POINT TO THE T2X LOCATION
01E2 8C 0012          CPX    #T23+3     / TIMER2 MEMORY BLOCK FULL?
01E5 27 04            BEQ    DONE       / BRANCH IF FULL

01E7 8D 03            BSR    LOG        / LOG COUNT, ADV POINTER
01E9 DF 16            STX    POINT2     / SAVE THE NEW POINTER

01EB 3B        DONE   RTI


               * THIS SUBROUTINE TRANSFORMS AND LOGS THE
               * MEASURED TIMES AND ADVANCES THE POINTER.

01EC 43        LOG    COM A             / COMPLEMENT THE COUNT TO GET
01ED 53               COM B             / HEXADECIMAL ELAPSED TIME
01EE 8D 5F            BSR    SAVE       / SAVE THE HEX ELAPSED TIME

01F0 86 80            LDA A  #$80       / SET BIT 7 TO SHOW THAT THIS
01F2 A7 00            STA A  0,X        / MEMORY LOCATION IS FILLED
01F4 8D 04            BSR    BD         / CONVERT HEX TIME TO DECIMAL

01F6 08               INX
01F7 08               INX               / ADVANCE THE POINTER TO THE
01F8 08               INX               / NEXT 3-BYTE MEMORY LOCATION

01F9 39               RTS
               * THIS ROUTINE CONVERTS THE 2-BYTE HEX NUMBER IN
               * 1,X AND 2,X TO A 3-BYTE DECIMAL NUMBER IN
```

Listing 2 continued on page 142

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8080/Z80 CP/M	C: $630 Pascal: $880	*	*	*
LSI-11/PDP-11: Idris, Unix, RT11, RSX-11/M, RSTS/E, IAS	C: $1130 Pascal: $1380	C: $630 Pascal: $880	*	C: $1130 Pascal: $1380
VAX-11 Unix/V32 VMS	C: $1130 Pascal: $1380	*	C: $630 Pascal: $880	C: $1130 Pascal: $1380
M68000 VERSAdos	*	*	*	C: $630 Pascal: $880

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Listing 2 continued:

```
                        * 0,X, 1,X AND 2,X.

01FA 7F 0012  BD      CLR    TEMP1     /TO HOLD 1000'S & 100'S COUNT
01FD 7F 0013          CLR    TEMP2     /TO HOLD 10'S COUNT

0200 8D 48    BD4     BSR    FETCH     / FETCH REMAINDER
0202 C0 10            SUB B  #$10
0204 82 27            SBC A  #$27      / SUBTRACT 10,000
0206 25 06            BCS    BD3       / BRANCH IF REMAINDER NEGATIV

0208 8D 45            BSR    SAVE      / SAVE REMAINDER
020A 6C 00            INC    0,X       / INCREMENT 10,000'S COUNT
020C 20 F2            BRA    BD4       / GO SUBTRACT ANOTHER 10,000

020E 8D 3A    BD3     BSR    FETCH     / FETCH REMAINDER
0210 C0 E8            SUB B  #$E8
0212 82 03            SBC A  #$03      / SUBTRACT 1000
0214 25 0A            BCS    BD2       / BRANCH IF REMAINDER NEGATIV

0216 8D 37            BSR    SAVE      / SAVE REMAINDER
0218 96 12            LDA A  TEMP1     / GET 1000'S COUNT
021A 8B 10            ADD A  #$10      / INCREMENT 1000'S COUNT
021C 97 12            STA A  TEMP1     / SAVE 1000'S COUNT
021E 20 EE            BRA    BD3       / GO SUBTRACT ANOTHER 1000

0220 8D 28    BD2     BSR    FETCH     / FETCH REMAINDER
0222 C0 64            SUB B  #$64
0224 82 00            SBC A  #$00      / SUBTRACT 100
0226 25 07            BCS    BD1       / BRANCH IF REMAINDER NEGATIV

0228 8D 25            BSR    SAVE      / SAVE REMAINDER
022A 7C 0012          INC    TEMP1     / INCREMENT 100'S COUNT
022D 20 F1            BRA    BD2       / GO SUBTRACT ANOTHER 100

022F 8D 19    BD1     BSR    FETCH     / FETCH REMAINDER
0231 C0 0A            SUB B  #$0A
0233 82 00            SBC A  #$00      / SUBTRACT 10
0235 25 0A            BCS    BD0       / BRANCH IF REMAINDER NEGATIV

0237 8D 16            BSR    SAVE      / SAVE REMAINDER
0239 D6 13            LDA B  TEMP2     / GET 10'S COUNT
023B CB 10            ADD B  #$10      / INCREMENT 10'S COUNT
023D D7 13            STA B  TEMP2     / SAVE 10'S COUNT
023F 20 EE            BRA    BD1       / GO SUBTRACT ANOTHER 10

0241 96 12    BD0     LDA A  TEMP1     / GET 1000'S & 100'S COUNT
0243 D6 13            LDA B  TEMP2     / GET 10'S COUNT
0245 EB 02            ADD B  2,X       / ADD REMAINDER TO 10'S COUNT
0247 8D 06            BSR    SAVE      / SAVE DECIMAL COUNTS
0249 39               RTS
                * THIS ROUTINE FETCHES THE NUMBER SAVED IN 1,X
                * AND 2,X.

024A A6 01    FETCH   LDA A  1,X
024C E6 02            LDA B  2,X       / FETCH THESE VALUES

024E 39               RTS


                * THIS ROUTINE SAVES 'A' & 'B' IN 1,X
                * AND 2,X.

024F A7 01    SAVE    STA A  1,X
0251 E7 02            STA B  2,X       / SAVE THESE VALUES

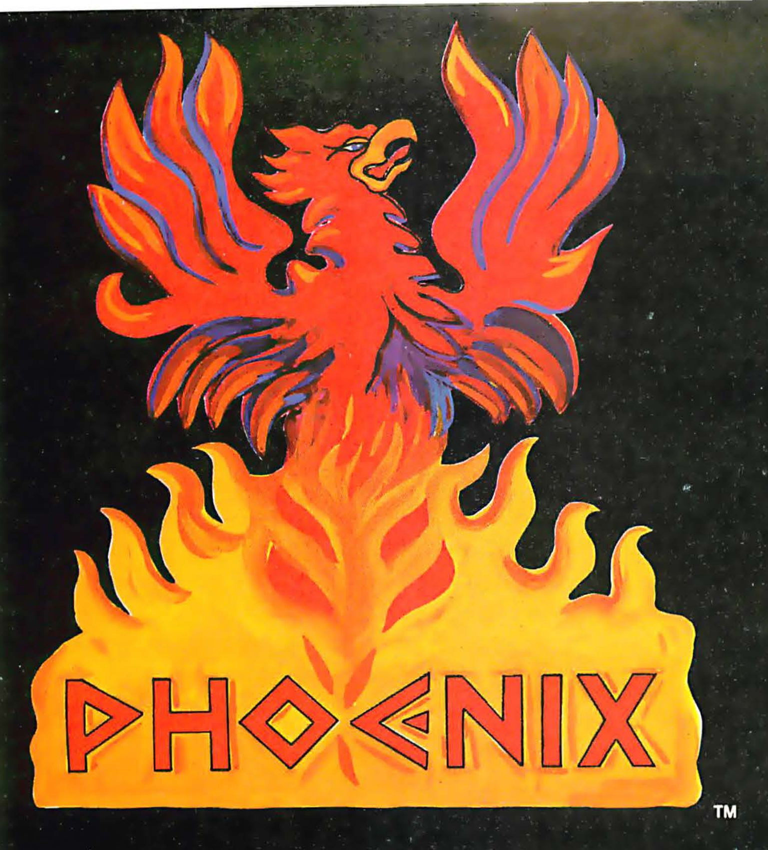
0253 39               RTS


                      END
```

SYMBOL TABLE

```
T11     0000  T12     0003  T13     0006  T21     0009  T22     000C
T23     000F  TEMP1   0012  TEMP2   0013  POINT1  0014  POINT2  0016
UIRQ    00F7  CR1     8000  CR2     8001  CR3     8000  STATUS  8001
M1      8002  L1      8003  M2      8004  L2      8005  M3      8006
L3      8007  REDIS   FCBC  OUTHEX  FE28  OUTCH   FE3A  ENCODE  FDBB
DSPLAY  FD7B  START   0100  CLEAR   012C  RUN     0134  SHOW    0147
SHOW1   014F  SHOW2   0158  SHOW3   015E  KEY     0168  KEY1    016A
KEY2    0173  SETX    0174  SETX1   0179  SETX2   0185  SETX3   0186
READOU  0187  READ1   01AD  READ2   01B2  RELEAS  01B3  REL1    01B5
POLL    01BE  POLL1   01C1  POLL2   01D6  DONE    01EB  LOG     01EC
BD      01FA  BD4     0200  BD3     020E  BD2     0220  BD1     022F
BD0     0241  FETCH   024A  SAVE    024F
```


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Text continued from page 134:

The demonstration program was used to time the motion of two colliding air cars on a linear air track. [*This apparatus is a cousin to an air-hockey table....RSS*] Each timer was controlled by one phototransistor illuminated by a 1 W incandescent bulb, and each air car carried an opaque vane 10 cm long (see photo 2). The vane blocked the light as the car passed in front of the phototransistor. With timers 1 and 2 operating in the pulse-width-comparison mode, the microcomputer measured how long each phototransistor was blocked as the cars approached and then recoiled from the collision. These measured times, the known lengths of the opaque vanes, and the cars' masses were then used to calculate momenta before and after the collision.

I required that each timer be able to record three elapsed times. Each timer therefore has three memory locations reserved for saving its measurements. Labeled T11 thru T23 in the demonstration program, these memory locations are accessed during readout as times A, B, and C for timer 1 and times D, E, and F for timer 2.

The trainer's six 7-segment LEDs (light-emitting diodes) are used for data display. Each experimental trial begins with the LEDs dark. The 7-segment LEDs then light individually to show letter labels of the elapsed times as they are measured (see photos 3 and 4). When the experimental trial ends, each of the keys A thru F, when pushed, will produce a display of the corresponding elapsed time (see photo 5). Pushing the zero key clears all six memory locations to prepare for another trial.

Although the demonstration program specifies operation of timers 1 and 2 in the pulse-width-comparison mode, it will just as easily support their operation in the frequency-comparison mode. To make the conversion, simply change the number stored at hexadecimal location 010D from hexadecimal 59 (for pulse-width-comparison mode) to hexadecimal 49 (for frequency-comparison mode).

Figure 6: *A complete circuit schematic diagram for the two-channel, data-logging, millisecond timer. This is designed to work with the Heath ET-3400 microprocessor trainer.*

Conclusion

This computer-based timer has been a stable and dependable measurement tool in my introductory physics laboratory. The students enjoy using it and appreciate the repeatability of results attained with it. I hope that you too will find it useful, and I would be interested to hear from readers who develop their own applications. ■

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Microcomputers in Education: A Concept-Oriented Approach

George Wolfe, James Madison University
Harrisonburg VA 22807

In the wake of new technologies, there generally comes an abundance of dreams and possibilities. Inherent in these possibilities is the seed of some new transformation of great or modest proportion. Such a transformation first occurs externally, manifesting itself in the conveniences or specialized abilities the new technology offers. But soon it touches us subjectively and we find ourselves perceiving reality differently. We construct new paradigms to help us understand our changed relationship with the world, and structure new vocabularies of experience.

Familiar examples of such technologies surround us—the electric light bulb, radio and television, satellite communication, medical technology, and nuclear energy. Each of these has altered our way of life to such an extent that any citizen of our culture from a century ago could not have entertained the world view we, by nature, have today. But, the technology that possesses the greatest potential to transform society and human life is just now entering the home: the microcomputer. Unlike some previous technological advances, the computer is not merely a specialized device fulfilling a specialized function. The convenience it provides is less tangible than bringing light into the home or Broadway entertainment into the living room. The computer's role and potential are much more abstract and profound. The new promise it offers is that of AI (artificial intelligence), which we not only create, but also, via the computer, communicate and interact with.

One of the most constructive fields to apply AI (to capitalize on its capacity to transform) is education. Various applications of microcomputers are already in the classroom and their effect has been found to be highly reinforcing to the learning process. These applications can be placed into the following categories:

- cataloging and processing of information
- learning to program a computer
- using the computer as an instructional tool; ie: CAI (computer-aided instruction)

The first two categories are self-explanatory and may even be somewhat familiar. There is no doubt that the computer can greatly increase the efficiency of a system through data processing, and that skill in computer programming is a growing necessity in our society. The third category may be somewhat less known, but clearly it is growing in use. It involves using computer programs designed to supplement students' assignments in the classroom. Such programs are usually in the form of drills, information exercises, or educational games. They often provide students with a moderate degree of interaction with the computer.

CAI has been defined in various ways and various opinions have been expressed as to its effectiveness. Certainly the value and success of CAI lies in the creative design of the programs and the appropriate setting for their use. Unfortunately, many teachers seem to view CAI as merely an automated drill instructor. Indeed, there is some value in having the computer play this role—it can hold pupils' attention and effectively reinforce their learning. Also, students learn to operate a computer long before any formal programming skill is acquired. But there is one application of CAI which as yet is relatively

About the Author

George Wolfe is a music graduate of Indiana University and has been teaching at James Madison University for the past three years. He is a member of the Association for Integrative Studies and has been privately researching integrative education and the role of the microcomputer in the classroom. Mr Wolfe has also been developing integrative arts related television programs on a grant from the School of Fine Arts and Communications at James Madison University.

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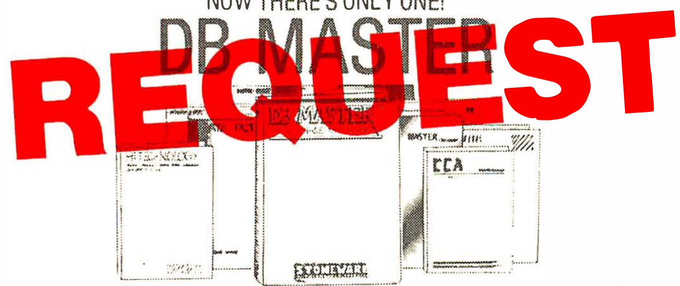
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unexplored. This is the use of the microcomputer to aid students in developing the ability to conceptualize. It is my belief that the transforming value of the microcomputer will be most fully realized through a concept-oriented approach to computer-aided instruction. The purpose of this article is to awaken educators to the solutions concept-oriented computer instruction offers our educational system.

Artificial Intelligence and Specialization

Inherent in the growth of technology is the need for specialization. New information and research, vocational training, and industrial development must accompany advancing technologies. Along with these also comes the expertise necessary to maintain that growth. With the surge of technological and industrial growth in the twentieth century modern education has shifted away from the liberal arts toward pragmatism and specialization. As this trend has increased the classical ideal of a liberal arts education has fallen by the wayside. (See reference 2, page 407.)

While certainly necessary in a technological society, there is a danger which emerges if specialization is carried too far. This danger is dependence and the loss of comprehensive viewpoints. We have seen how a technological society can become dangerously dependent on foreign energy sources needed to drive that society and maintain its standard of living. We have also witnessed how the interaction among nations, motivated by their own individual interests, demands a perspective in world leaders that must be holistic if a stable peace is going to be achieved and sustained. Thus, the many specialized technologies that have brought nations closer together and made them dependent on one another have ironically recreated the need for the Integrated Person; someone who is able to recognize and effectively apply fundamental concepts to numerous, rapidly changing, and adaptively taxing circumstances. Such an individual must necessarily possess a more comprehensive understanding of the various academic disciplines, so that he or she can make decisions that are universally beneficial.

The common belief among educators today is that this *ideal* is impossible to achieve. It certainly appears that way when we examine the flood of information present within every discipline. Education, in keeping pace with technology, has become so oriented toward information gathering and retention that the conceptual links among

Education Forum is an occasional feature in BYTE intended to foster debate about the uses of personal computers in the schools and colleges. We encourage reader participation. Contributors should supply their full names and addresses for publication, along with their telephone numbers, which will not be published.

the academic disciplines have been all but lost. The advent of artificial intelligence has the potential to change this, because computer technology provides a means through which information within all disciplines can be effectively handled, processed, and made available. It turns out that mechanical brains manage information better than human brains (ie: a computer's memory and processing capabilities are in many ways superior in efficiency and organization to our own). Thus, the availability of information can be increased in quantity and reliability with microcomputers in the learning environment. The preoccupation of education with information can now be relieved somewhat. Rather than gearing students primarily for absorbing and retaining data, their attention can be directed toward the abilities to conceptualize, abstract, and apply available information creatively. These higher abilities remain uniquely human. We should no longer neglect their formal development for the sake of having students retain enormous amounts of information.

A movement in American education dedicated to promoting a concept-oriented approach to teaching began several decades ago with a small circle of scientists, most of whom had been strongly influenced by general systems theory. Among this group's members were Henry Margenau of Yale University and author-scientist Ervin Laszlo. Their efforts enjoyed a brief period of international recognition during the 1950s and 1960s under the auspices of the Center for Integrative Education. (See reference 1, pages v thru vii.) Their ideas have never been fully realized in the American classroom, but the microcomputer now makes the fulfillment of their approach a definite possibility. The computer is certainly the catalyst through which the integration of knowledge can be achieved in modern education and the direction of teaching changed to include principles and fundamental concepts, as well as specialized information.

Fundamentals of an Integrative Approach

The first and foremost demand of concept-oriented education is the development of thinking skills. Today, we devote much time to cultivating reading and mathematical skills, artistic abilities, and other talents in our students. But we tend to ignore the abilities to think rationally, evaluate circumstances and information accurately, and integrate two or more disciplinary perspectives. As a result, high school and college students often lack the intellectual faculties needed to grasp issues in a sharp and accurate focus.

As with other abilities, developing thinking skills takes practice, something teachers do not always have the time and understanding to offer. Properly structured and applied computer programs, however, can provide the time and mental exercise needed to sharpen students' reasoning faculties.

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It is possible, for example, to develop a series of logic programs ranging in difficulty from simple reasoning using concrete ideas, to complex reasoning employing abstract ideas. The relationship between logical and mathematical proof can also be incorporated into such programs. The format could be a kind of logical dialogue between student and computer. For example,

Computer: What do you say to us having a philosophical discussion? I'll start by making a simple statement, and you tell me if you think it is true or false.
"Seeing is believing."

Student: True.

Computer: I take it then, that if you see something, you believe it to be really happening or really there. Is this correct?

Student: Yes.

Computer: OK. So far you are thinking very logically. But now, let me ask you another question.
"Have you ever seen the sun rising in the morning sky?"

Student: Yes.

Computer: Do you know that the sun is not actually rising in the sky? What is actually happening is that the Earth is revolving on its axis, and in doing so, creates the illusion that the sun is moving upward. Now that I have pointed this out, do you still believe the sun is really rising in the sky?

Student: No.

Computer: But do you still see the sun rising in the morning sky?

Student: Yes.

Computer: Well then, you have to reconsider my original statement which was "seeing is believing." You said that this was a true statement, yet you just admitted that even though you have seen the sun rise in the morning sky, it is not really rising.
Do you still think that in all cases "seeing is believing."

Student: No.

Computer: Very good! We simply have to recognize that illusions do exist and that seeing something does not always mean that what we are seeing is really happening or really there.... Now consider this next statement.
"The sun appears to be rising in the sky."
Is this statement true or false?

Student: True.

Computer: Correct. The word "appears" is what makes the statement true because it suggests that the rising sun is indeed an illusion.

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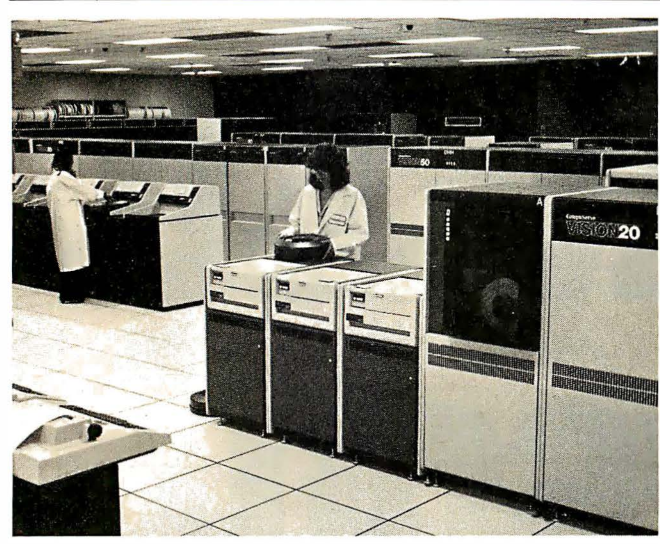
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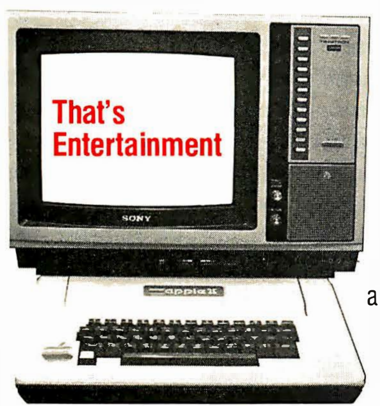
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Education Forum

Another series of programs can be composed to help students learn to discriminate between objectively, rationally, and intuitively derived conclusions. The aim is to develop discernment in the student and provide the time and practice necessary for one to become adept at applying such thinking skills.

Interdisciplinary perspectives can be the theme of still another thinking-model program. Here, the goal is to arrive at the most plausible explanation for something by considering information from various disciplines. For example, students examine explanations based on economic influences, historical factors, or any other perspectives that are appropriate to the subject being considered.

Such a program, in addition to the ones mentioned above, can be designed for educational levels ranging from junior high school through college. (Anyone interested in more information regarding the programs discussed in this article can write the author in care of the Music Department, James Madison University, Harrisonburg VA 22807.)

With thinking skills heightened, we are now ready to pursue the second most important aspect of integrative education, concept development. Concept development often utilizes basic rules and principles, many of which have several exceptions. The idea is for the students to find the exceptions and be able to adapt the principles to suit varying circumstances. To illustrate this, let us compare the steps of an information-oriented approach to a concept-oriented one.

The information-oriented approach is basically an inductive one. That is, we begin by giving out specific facts and data, then we draw conclusions, and finally derive our concepts. (Unfortunately, many teachers today never follow through to the final step of deriving the basic concept!) A concept-oriented approach is deductive rather than inductive. After prerequisite definitions are given, students are taught a generalized concept. From there, students speculate on probable conclusions and hypotheses, then search out the necessary information in an effort to test the conclusions. What the deductive, concept-oriented approach develops is the ability to apply a general concept, and the skills to resourcefully and efficiently locate the information needed to test one's speculative conclusions. To accelerate, simplify, and reinforce this process, the needed information could be made available through a computer retrieval system.

Let us consider how this method can be employed within a discipline through the use of the microcomputer. The following example pertains to basic music theory. The prerequisite information required of the student are knowledge of the definition and labeling of music intervals, the definition of a triad, and how to read treble clef.

Computer: Now I am going to show you how to derive various types of triads by teaching you a simple harmonic concept. This concept is:
"Triads are built with intervals."

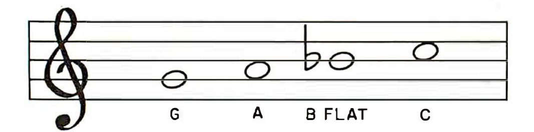


Figure 1: *See text for details.*

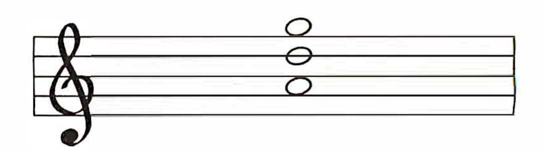


Figure 2: *See text for details.*

This means that by choosing an interval, and stacking notes on top of one another at the interval you have selected, you can form various types of triads and harmonic textures.

Let us begin by selecting one of the following notes on the treble clef staff shown in figure 1.

Student: A.

Computer: Now choose one of the following intervals:
- second
- third
- fourth
- fifth

Student: Fourth.

Computer: Very good. Now build the triad out of fourths using the note you selected as the root of the chord. (List the two added notes.)

Student: D and G.

Computer: Correct! (See figure 2.) Because this triad is built in fourths, it is called a quartal triad. Quartal harmony has been used by many twentieth-century composers. Now check the text file for information on quartal harmony and answer the following questions....
Now choose another interval...(etc)

Computer: This is a basic principle for building triads. Usually, students only learn about tertian harmony (chords built in thirds) in the early years of music theory. But by using this concept, you can jump ahead and learn to write triads which are usually considered advanced...

A third important element of concept-oriented education is the interdisciplinary transfer of knowledge. Here, we are dealing with unifying relationships among disciplines, usually closely related disciplines. In the arts for example, there are certain fundamental aesthetic elements that are common to media. Among these are contrast, intensity, and proportion. The techniques used to employ these elements in an artwork are different for every medium, but the aesthetic purpose served is essentially the same. Microcomputer programs could be developed to teach such interdisciplinary, isomorphic relationships. If used early enough in a child's education, a network of unity could be structured among the disciplines. Then, even when specialization becomes necessary later on, a holistic perspective would always remain with the student.■

References
1. Margenau, Henry. *Integrative Principles of Modern Thought.* New York: Gordon and Breach, 1972.
2. Meyer, Adolphe E. *An Educational History of the American People.* New York: McGraw-Hill, 1967.

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The phrase "we interrupt this program to bring you an important announcement" is as applicable to computers as it is to radio or television. The interrupt system of a computer stops the program being processed to perform a more important task.

What is an interrupt? It is a computer control-signal input that is sampled by the microprocessor during every instruction cycle. If an external device has *asserted* (activated) the interrupt line, the microprocessor will cease processing the normal flow of instructions, put an *interrupt vector* on the address lines, and load the program counter with the address pointed to by the interrupt vector. The microprocessor can then begin execution of the interrupt-handling program found at this address.

Simply stated, an interrupt is a forced, immediate branch to some specified memory address in response to an externally generated control signal. A computer system will generally use additional hardware to implement a number of possible interrupts, each with its own priority and interrupt-handling routine.

Why Interrupt?

At present, few microprocessor-based systems are interrupt driven. Any program requiring I/O (input/output) operations, or timing functions, must employ a timing loop (a sequence of instructions that takes a known interval to execute) until the operation is complete. As an example, writing eighty characters to a teletypewriter at a rate of 110 bits per second would require about eight seconds. The processor uses most of this time to constantly sample the *transmitter ready* status of the interface involved. In eight seconds, an 8080A microprocessor could process about four million instructions. As you can see, sitting in a status-checking loop is not an efficient processing method.

Now suppose that the transmitter-ready signal from the interface is used to assert the interrupt line to the microprocessor. Whenever the interface is ready to accept another character, the processor is forced to branch to the output routine. It sends the next character, then returns to the main program. For the specific example we are using, this fairly simple procedure results in making four million additional instruction periods available.

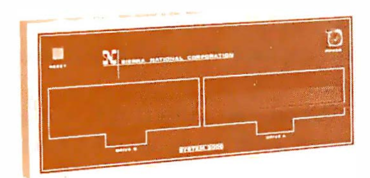
Obviously, in many low-level applications, it really doesn't matter how much time is spent in an I/O loop because the user won't be proceeding with the program until the output is complete. However, in many higher-level applications, such as multiprogramming and high-speed instrumentation programs, it becomes imperative that the processor not be tied up. Interrupt-driven software and hardware become essential. Multiuser, multiprogramming systems become feasible only in an interrupt-driven environment.

Any programming that requires timing or periodic functions can also benefit from the use of interrupts in conjunction with a programmable timer. Tasks such as keyboard scanning or display refreshing are very simple to accommodate using an interrupt system. There is very little impact on the main program task by occasional interrupts, and a little software can replace additional hardware.



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Multiple programs can also run under an interrupting, time-sharing system. Each program may be assigned a certain percentage of the total processing time. A timed interrupt and executive routine are used to *rotate* the processor between programs. The executive program, from which the interrupt branches, acts as a "traffic cop" to give each program its fair share of time.

Multilevel Interruption

A computer system generally has several interrupting devices. To sort out these interrupts a priority scheme is generally used. The priority scheme assigns each device in the system a priority level, according to its importance. This allows the most important I/O devices to be serviced before those of lower priority. Except in the simplest interrupt implementations, a higher-level interrupt is allowed to interrupt the current routine of a lower-priority interrupt. In this way, several interrupt routines could conceivably be nested in a busy system.

Most microprocessors have only one general-purpose interrupt input, and external hardware must be used to resolve priorities between the various interrupt lines. The hardware may also provide for additional functions, such as individually selectable interrupt levels and nesting of interrupts. The hardware involved in a very simple interrupt system is shown in figure 1a. In this system, once an interrupt occurs, the interrupt system should remain disabled until completion of the interrupt routine. With this very simple implementation a high-level interrupt may not interrupt a lower-level routine once it is in progress.

For an interrupt to be recognized by the microprocessor an *enable interrupts* instruction must have been previously executed by the program. Additionally, some devices will require that a special interrupt register be set with the proper vectoring data. When an interrupt is recognized, the contents of the program counter will be pushed onto the stack, and the start address of the interrupt routine will replace the old program-counter data.

When an interrupt occurs, the return address is saved on the stack, and the processor branches unconditionally to the interrupt routine. The microprocessor will also disable its internal interrupt system whenever an interrupt occurs. Software must enable interrupts again before other interrupts will be recognized by the device.

An interrupt routine should also do some housekeeping to insure a successful return to the interrupted program. First, the contents of all the registers should be saved so that their contents can be restored prior to resuming the interrupted program. Depending upon your hardware, you may need to output the priority level of the current interrupt for comparison with incoming interrupts.

In the case of serial devices, such as terminals or cassette decks, the microprocessor is usually interfacing with a UART (universal asynchronous receiver-transmitter). These devices have signals indicating "receiver ready" and "transmitter ready" to assert interrupt lines. The signals can be used as independent interrupts (one per device) or can

be combined into a single interrupt. In the latter case, software can examine the device status to determine the required operation. The act of servicing the UART will clear the condition of the signals.

In dealing with parallel devices such as printers, the usual feedback is in the form of a "busy" signal; inverted, this becomes a "ready" signal that can be used to generate an interrupt. Here again, servicing the device will clear the interrupt signal.

In a good system, the interrupt hardware will allow interrupt nesting and individual selection of interrupts (see figure 1b). The computer interrupt system is a truly useful and efficient tool for increasing the throughput and general capabilities of a microprocessor-based computer system. With interrupts a whole world of high-level applications, such as multiuser systems, becomes feasible. Once understood, the interrupts system becomes an indispensable programming tool. ■

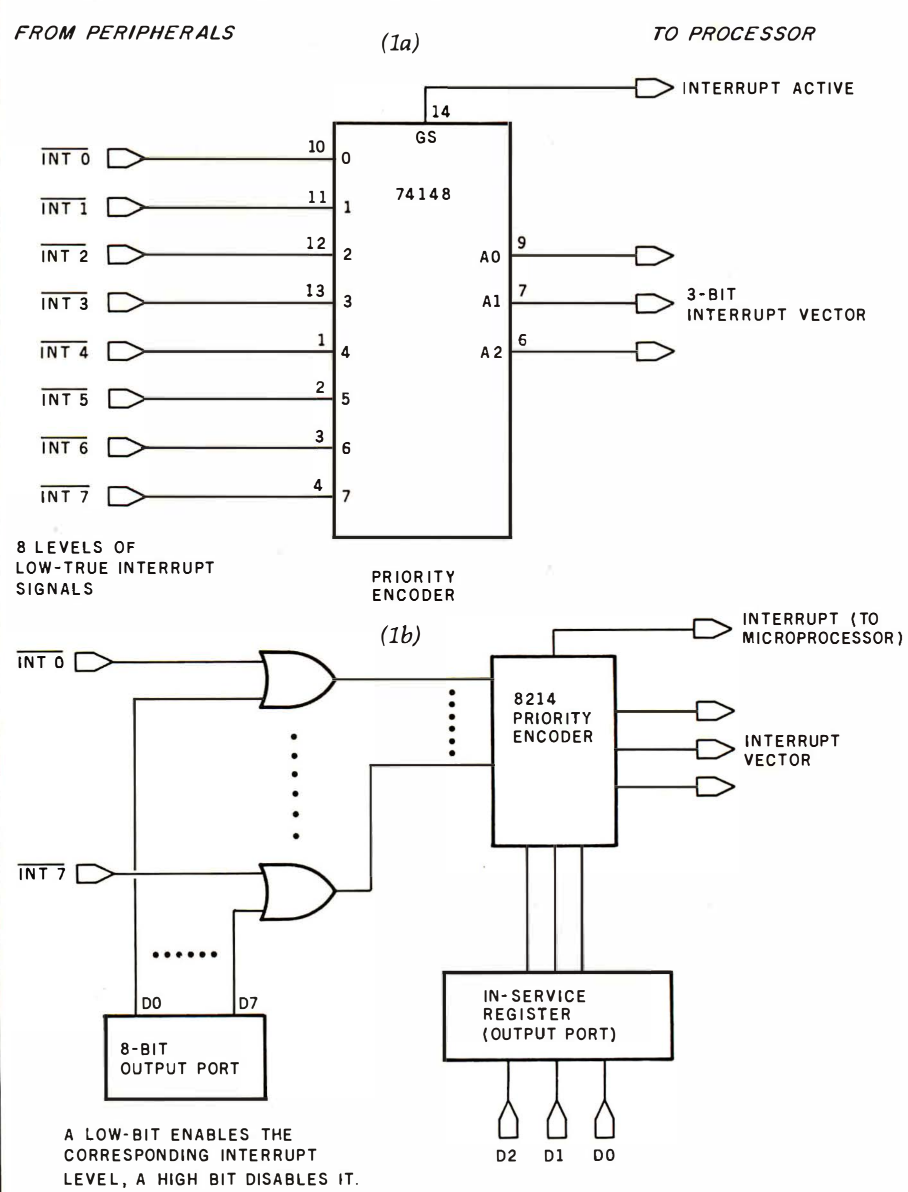


Figure 1: *Hardware for handling multiple-level interrupts. This system allows a computer to handle the requests of peripheral devices in order of priority. The arrangement in figure 1a has the capacity to service eight separate priority levels. Each interrupt is completed before others are allowed. A more sophisticated scheme is shown in figure 1b. It has the ability to halt current interrupt service if a higher-level interrupt occurs (when the higher-level interrupt is finished, control is returned to the lower-priority interrupt and its service is completed).*

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Z80 Table Lookup

Thomas McCloud, 26572 Hickory Ave, Hayward CA 94544

Among the problems familiar to experienced programmers is that of table lookup: given a value (the argument, or *key*), search through a list of values of the same kind to find a matching entry. Then, once a match is found, extract the corresponding entry (the function, or *result*) from a second list, often of a different kind of data. This article discusses a single table-lookup routine (written specifically for a Zilog Z80 microprocessor) that, given an 8-bit value, finds a corresponding 16-bit value. As such, this article is of primary interest only to Z80 programmers. But it shows them how the special instructions peculiar to the Z80 can be used to good effect.

The routine, ZTL, is shown in listing 1. It achieves a great economy of program size, and a good economy of execution time, by using the special Z80 block-search instruction, CPDR (Compare, Decrement and Repeat). The similar search instruction, CPIR (Compare, Increment and Repeat), may seem more natural to use. But for the routine presented here, CPDR provides more easily used "leftover information" in the BC register pair.

To show how the routine works, consider the following example. A computer-system monitor is being written. The system user types a single character command, and the system responds by performing an indicated action. The commands are:

I — Initialize system
D — Display hexadecimal memory dump
G — Get a file from external media
X — Execute a program
E — Enter hexadecimal data into memory
B — Set a breakpoint

Some of the commands need additional data, such as the address at which a breakpoint is to be set. However, the only current concern is to identify the command and branch to the address of the corresponding command-handling routine. Listing 2 shows the memory arrangement of the table for ZTL. (Values given for the addresses of the command-handling routines are purely arbitrary.)

The call to use the ZTL routine is shown in listing 3. Listing 4 shows a step-by-step illustration of the contents of each register involved, assuming that the program has extracted a G command from the typed input.

The first two instructions simply copy the contents of the BC register pair (used to hold the byte count) into the DE register pair (to be used later). The next instruction is the Z80 CPDR. It is executed four times in the current example. On the first execution, the G in register A is compared to the B at the location (hexadecimal 12F5) indicated by the HL register pair, the contents of HL are decremented from hexadecimal 12F5 to 12F4, and the byte count is decremented from 6 to 5. Since the bytes compared did not match, and the byte count did not go to zero, the instruction is repeated, using the new values in the HL and BC register pairs.

On the fourth execution of the CPDR instruction, the G in register A is compared to the G at the location indicated by the HL register pair (hexadecimal 12F2), the contents of HL are decremented from hexadecimal 12F2 to 12F1, and the byte count is decremented from 3 to 2. Since the bytes compared did match, the instruction is not repeated. Notice that the HL register no longer points to the G in the table; it points one location below the G. This is a nuisance caused by Zilog's choice of a "post-test

loop" approach instead of a "pre-test loop." It is not difficult to compensate for it, but it is easy to forget.

The next instruction executed is a RET NZ (return on not zero), which provides an exit when the byte for which a match is sought does not occur in the table. In the current example, this return is not taken. Following the RET NZ is an instruction to increment the contents of the HL register pair. This instruction is used to compensate for the incorrect value stored in the HL register, described above.

The next two instructions compute the address of the first (low-order due to high/low storage reversal) byte of the sought argument—the corresponding entry in the second part of the table. Suppose B is the beginning address of the first part of the table, L is the length of the first part of the table, and I is the position of the sought byte in the table, I ranging from 1 to L. The second part of the table starts at address $B + L$, and the sought entry starts at address $B + L + (I - 1) \times 2$. At this point in the execution of the routine, BC holds $I - 1$, because the CPDR decrements the byte count once too often, as well as the address in HL. Furthermore, the address in HL is $B + (I - 1)$ (compensated). So, when the routine adds BC to HL:

$$HL = B + (I - 1) + (I - 1)$$

Then, adding the table length L, saved in DE:

$$HL = B + (I - 1) + (I - 1) + L$$

so:

$$HL = B + L + (I - 1) \times 2$$

which is the address of the sought argument.

Text continued on page 174

Listing 1: *ZTL, a table-lookup routine for the Z80 microprocessor. The use of the Z80's block-search instructions makes this routine short and fast, but some of the microprocessor's idiosyncrasies need compensation.*

```
;NAME: ZTL
;PURPOSE: Z80 TABLE LOOKUP
;INPUTS: A  = ARGUMENT (BYTE VALUE FOR WHICH
;             WORD VALUE IS TO BE FOUND.)
;        BC = LENGTH OF TABLE ARGUMENT LIST
;        HL = ADDRESS OF LAST TABLE ARGUMENT
;NOTE: TABLE MUST CONSIST OF AN ARGUMENT LIST OF
;      SINGLE-BYTE ENTRIES, FOLLOWED BY A FUNCTION
;      LIST OF CORRESPONDING SINGLE-WORD ENTRIES.
;      (WORDS STORED WITH USUAL LOW-HIGH BYTE
;      INVERSION.)
;OUTPUTS: IF NO MATCH FOUND FOR INPUT:
;           ZERO FLAG OFF (NZ)
;         IF MATCH FOUND FOR INPUT:
;           ZERO FLAG ON (Z)
;           HL = VALUE FROM CORRESPONDING
;                FUNCTION ENTRY
ZTL:    EQU   $
        LD    D,B     ;COPY LENGTH FROM BC
                      ;(BYTE COUNT) . . .
        LD    E,C     ;. . . INTO DE (TO SAVE FOR LATER)
        CPDR          ;SEARCH DOWN ARGUMENT ENTRIES
        RET   NZ      ;"NOT ZERO" MEANS NO MATCH
                      ;FOUND
;NOTE THAT NONE OF THE FOLLOWING CHANGES THE
;ZERO FLAG
        INC   HL      ;COMPENSATE FOR CPDR OVERSHOT
        ADD   HL,BC   ;ADD REMNANT OF BYTE COUNT
        ADD   HL,DE   ;ADD ORIGINAL LENGTH
;AT THIS POINT THE HL REGISTER PAIR POINTS TO THE
;DESIRED FUNCTION ENTRY
        LD    E,(HL)  ;PICK UP LOW-ORDER BYTE
        INC   HL
        LD    D,(HL)  ;PICK UP HIGH-ORDER BYTE
```

Listing 1 continued on page 172

Listing 1 continued:

```
        EX      DE,HL  ;PUT RESULT INTO HL (MORE
                        USEFUL THERE)
        RET            ;DONE
```

Listing 2: *Arrangement of the table in memory for use by ZTL.*

ADDRESS	DATA	
12F0	49	[LETTER "I"]
12F1	44	[LETTER "D"]
12F2	47	[LETTER "G"]
12F3	58	[LETTER "X"]
12F4	45	[LETTER "E"]
12F5	42	[LETTER "B"]
12F6	00	[INITIALIZE ROUTINE AT ADDRESS 0000]
12F7	00	
12F8	AA	[DISPLAY ROUTINE AT ADDRESS 06AA]
12F9	06	
12FA	0B	[GET ROUTINE AT ADDRESS 070B]
12FB	07	
12FC	12	[EXECUTE ROUTINE AT ADDRESS 0112]
12FD	01	
12FE	08	[SET BREAKPOINT ROUTINE AT ADDRESS 0A08]
12FF	0A	

Listing 3: *Sample of the call to ZTL.*

```
        .
        .
        .
[NOTE: AT THIS POINT IT IS ASSUMED THAT REGISTER A
ALREADY CONTAINS THE ASCII CHARACTER "G", EX-
TRACTED FROM INPUT, FOR WHICH THE TARGET ADDRESS
IS TO BE FOUND.]
        LD      BC,6        ;LOAD LENGTH OF ARGUMENT
                             TABLE
        LD      HL,12F5H    ;ADDRESS OF LAST TABLE ENTRY
;FIND ADDRESS IN FUNCTION TABLE CORRESPONDING TO
;BYTE IN A
        CALL    ZTL         ;Z80 TABLE LOOKUP
        JP      (HL)        ;GO TO THE ADDRESS SO FOUND
        .
        .
        .
```

Listing 4: *Register contents as ZTL executes (see the text for an explanation of the specific example).*

```
INSTRUCTION           REGISTER CONTENTS              TABLE BYTE
EXECUTED          A   Z-FLAG   B  C  D  E  H  L        (HL)
ZTL ROUTINE CALLED
                  47    ??     00 06 ?? ?? 12 F5        42
   LD      D,B  ;COPY LENGTH FROM BC (BYTE COUNT)...
                  47    ??     00 06 00 ?? 12 F5        42
   LD      E,C  ;...INTO DE (TO SAVE FOR LATER)
                  47    ??     00 06 00 06 12 F5        42
   CPDR         ;SEARCH DOWN ARGUMENT ENTRIES
                  47    ??     00 05 00 06 12 F4        45
   CPDR         [INSTRUCTION REPEATS ITSELF]
                  47    NZ     00 04 00 06 12 F3        58
```

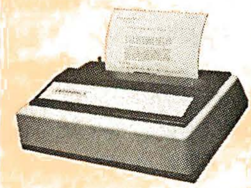
Listing 4 continued on page 174

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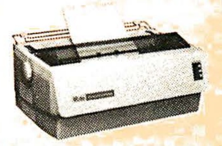


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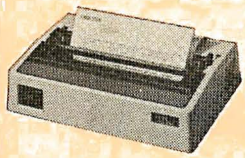
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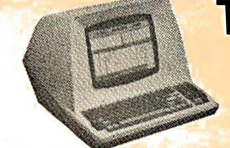
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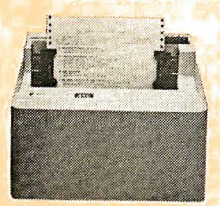
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Listing 4 continued:

```
CPDR        [INSTRUCTION REPEATS ITSELF]
               47    NZ      00 03 00 06 12 F2      47
CPDR        [INSTRUCTION REPEATS ITSELF]
               47    Z       00 02 00 06 12 F1      44
RET    NZ  ;"NOT ZERO" MEANS NO MATCH FOUND
               47    Z       00 02 00 06 12 F1      44
INC    HL  ;COMPENSATE FOR CPDR OVERSHOT
               47    Z       00 02 00 06 12 F2      47
ADD HL,BC ;ADD REMNANT OF BYTE COUNT
               47    Z       00 02 00 06 12 F4      45
ADD HL,DE ;ADD ORIGINAL LENGTH
               47    Z       00 02 00 06 12 FA      0B
LD  E,(HL) ;PICK UP LOW-ORDER BYTE
               47    Z       00 02 00 0B 12 FA      0B
INC    HL
               47    Z       00 02 00 0B 12 FB      07
LD  D,(HL) ;PICK UP HIGH-ORDER BYTE
               47    Z       00 02 07 0B 12 FB      07
EX  DE,HL  ;PUT RESULT INTO HL (MORE USEFUL THERE)
               47    Z       00 02 12 FB 07 0B      ??
RET   ;DONE
               47    Z       00 02 12 FB 07 0B      ??
```

Text continued from page 170:

The next instructions pick up the low-order byte, increment HL, and pick up the high-order byte of the sought argument word. They are put directly into the DE register pair by means of the HL register indirect instructions. If the answer is useful in DE, the routine can be ended here with a return; but, since an answer is generally more useful in the HL register pair, the routine as shown includes an exchange of DE with HL.

Finally, the routine ends with a simple unconditional return statement. It is important to note that *none* of the instructions following the CPDR will affect the zero flag. This allows the calling routine to easily determine if a match was found by examining the zero flag. The fact that the 16-bit ADD (without including previous carry) instructions do not set the zero flag is often a nuisance. But in this routine it is an advantage.

Beyond Tables

This article described a simple routine with a great deal of power. The example of usage presented dealt with finding the address of a software routine when given a single character command. However, the same routine can be called whenever you want to find 16 or fewer bits of information from a single 8-bit value. For example, it could be used to interpret single-byte codes used to store 3-digit telephone prefixes. Or it might be useful in a compiler to store a table of kinds of variables and their attributes. Hopefully, you will find that problems of your own can be solved with this simple and efficient routine.■

Four Word Processors for the Apple II

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Bedford MA 01730

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14 Larchmont Dr
Nashua NH 03062

The world of word processors has expanded rapidly in the past few years, and it appears to be only the beginning. We have seen a flourish of office automation machines from the big manufacturers, but with few exceptions the small machine software manufacturers have led the way. And, after reviewing some of the word-processing systems designed for microcomputers, we discovered that they have several advantages.

It was a temptation when reviewing these word processors to compare them to their large mainframe brothers. Eventually we stopped resisting that temptation. Both Steve and I have access in our work to such mainframe word processors as those by Wang and Honeywell. The comparison hardly seems fair, but in reality most of the microcomputer word processors offer the features found in their larger brothers: in fact, a few of them are easier to use and learn, while still providing all of the features a user could possibly want. This will be evident in specific reviews.

There are two kinds of word processors: *screen-* or *cursor*-oriented, and *line*-oriented. Cursor-oriented means that the editing and entry take place at the cursor, which is moved throughout the text. In line-oriented word processors, all text is entered and referred to with line numbers. Neither method appears to have a distinct advantage over the other: they are merely different ways of referencing the text.

Super-Text

Super-Text is a super word processor that, despite minor problems, exhibits some of the power-packed features you would expect in a word processor designed for a much larger machine. Super-Text (from Muse Software) can be easily adapted to your current equipment, as well as any you may acquire in the future.



Photo 1: *Apple word processors: the Datacope Scribe, the Rainbow Write-On!, the IUS EasyWriter Professional system, and the Muse Super-Text II. (The cream-colored binder in the upper left corner is for Super-Text I, which has been discontinued by Muse.)*

At a Glance

Name
Super-Text II

Type
Word processor

Manufacturer
Muse Software
330 N Charles St
Baltimore MD 21201
(301) 659-7212

Price
$150

Format
5-inch floppy disk

Language
6502 machine language

Computer
Apple II or II+ with 48 K bytes of memory and one disk drive

Documentation
82 pages, 15.5 by 23 cm (6 by 9 inches); three-ring binder

Audience
Anyone needing a word-processing system

Circle 223 on inquiry card. →


baZic

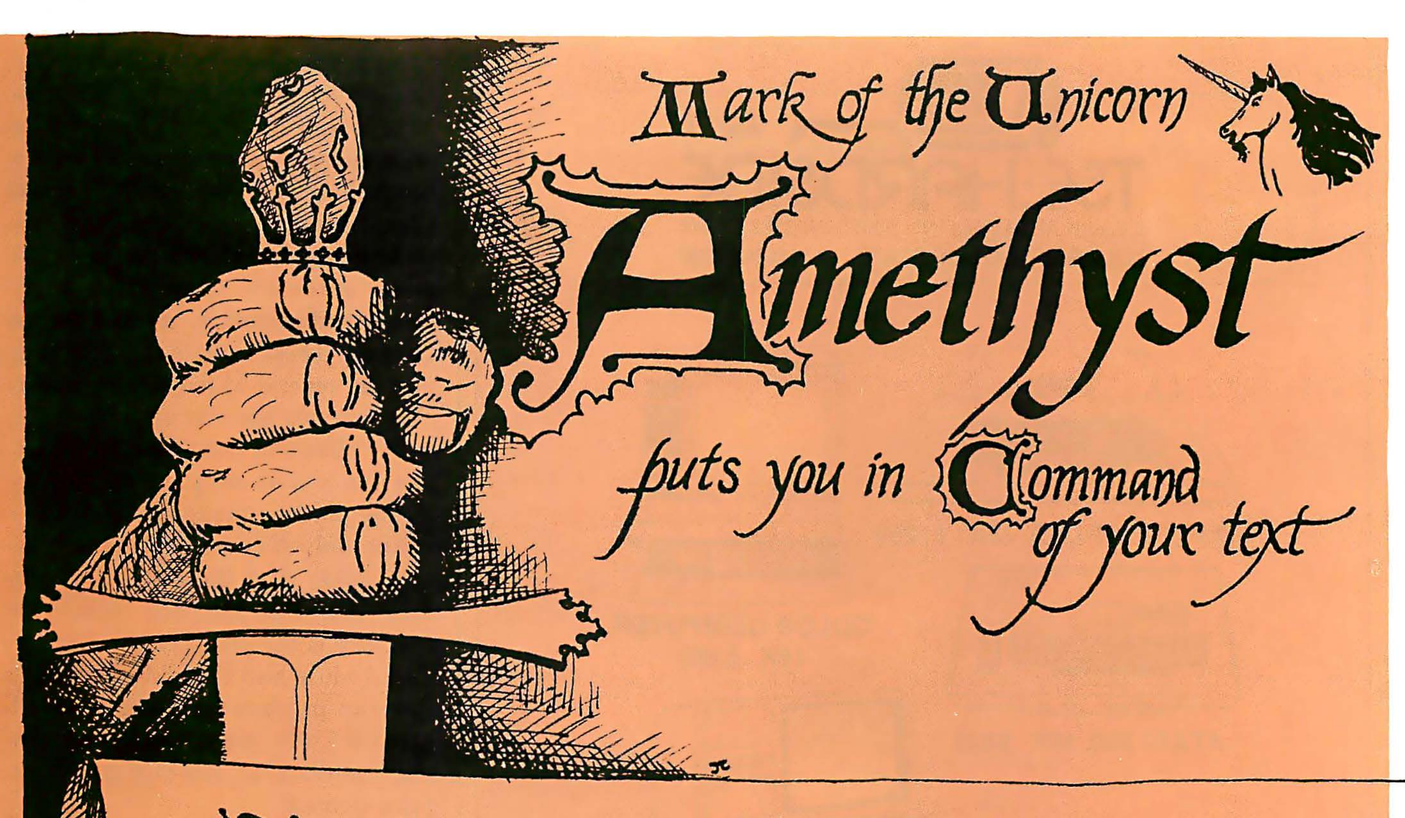
With the Dan Paymar lowercase adapter (which allows the Apple to display lowercase letters), this processor supports true lowercase.

Super-Text also allows conversion of files for use with the Paymar lowercase adapter. However, it does not allow the reverse, so you must either keep two copies of the text file or always use an Apple II with the lowercase adapter. Most of the other Apple II word processors use reverse-video to represent uppercase letters on the screen. If you don't have a Paymar lowercase adapter, Super-Text places a reverse-video A in front of the character to be capitalized, instead of highlighting the character itself. This can be confusing until you get used to it, because the reversed A does not print when you print the file. We found that we had a tendency to compensate for the nonprinting character when lining up text. You have to use the control key as a shift, but Super-Text will support the use of the shift key with a minor modification to the keyboard. (Muse provides the short piece of wire and instructions for the modification.)

Super-Text does not support an 80-column board, but it simulates 80 columns by using a preview mode. This mode allows you to see what your text will look like on paper, with obvious limitations on color, super-/subscripting, and underlining. (In any case, these limitations are dependent upon the printer that you use.)

Since you can only see the leftmost 40 columns on the screen, the preview mode allows you to move the left margin to the right to see the other half of the document; however, we found the operation awkward to use because the text scrolls past quickly. Still, this arrangement is better than wasting paper to see what you have written.

Super-Text uses the wraparound method of text entry (ie: if a word will not fit on a line, the entire word is automatically moved to the next line). Some word processors use a



Talk with Amethyst about words, sentences, paragraphs, chapters, quotations, footnotes, and more—it understands. Its ability to edit <u>and</u> display several documents and programs at once is <u>absolutely</u> unequaled by <u>any</u> other system.

Amethyst can be modified to suit <u>your</u> needs because we supply the source for the commands. You can <u>arbitrarily</u> alter the behavior of any command!

One year's support is <u>included</u>—we don't leave you to fend for yourself. And our thorough, readable documentation has received high acclaim from our users. Amethyst comes with the BDS C compiler. How many other word processing systems let you write programs as well?

Amethyst $350 (less C compiler $250) manual $35

Mince (Amethyst text editor) $125 manual $15 demo disk $10
Scribble (Amethyst text formatter) $125 manual $15
Mince and Scribble ordered together $175

48K CP/M[R] required. Available on 8" soft sector diskettes. Mince and Amethyst require a cursor-addressable terminal. Dealer, site, OEM, and **NIX versions and licenses available.

Mark of the Unicorn, P.O. Box 423, Arlington, MA. 02174 (617)489-1387

"hot zone" to prompt for hyphenation, but if you want hyphenation with Super-Text you must perform it manually. By embedding control characters in the text, you can instantly invoke format changes, tab stops, automatic paragraph indentation, word centering, and left margin changes. These control characters appear as reverse video letters. Super-Text formats the text upon printout, so the effects of these control characters are visible only on printout or during preview mode.

The only files Super-Text will accept, other than those written by itself, are Dr Memory files. (Dr Memory is the predecessor of Super-Text.) Muse also has add-on modules that can produce form letters (available for $100), input files by telecommunication ($75), and plot graphs (no price quoted).

Super-Text's ability to edit is excellent. The word processor is cursor-oriented, and it gives the user a full set of commands to move the cursor about the text. The cursor scrolls backward or forward by operator choice, and the direction is clearly marked in the lower left-hand corner. The replacement, deletion, insertion, and rearrangement of text processes are all easy to use and understand. However, one minor problem appears with insertion: normally insertion occurs in front of the current cursor location—with Super-Text, it occurs *after* the cursor location. This is unnerving and hard to get used to. Super-Text can also copy blocks of text easily throughout the text file, and it can save and load blocks of text separately, a feature that is especially helpful with "boilerplate" files used in business correspondence.

Find-and-replace operations are easy and efficient. The operations even include a "wild card" notation that will match any number of intervening characters (including none). For example, an attempt to find "COMPUT#WORLD" would match "COMPUTER WORLD" or "COMPUTING WORLD". Super-Text is loaded with prompts that make find-and-replace operations easy for the operator.

DYNACOMP

Quality software for⁺:

ATARI	**TRS-80 (Level II)***
PET	**NORTH STAR**
APPLE II Plus	**CP/M 8" Disk**

GAMES, SIMULATIONS, EDUCATION and MISCELLANEOUS

BRIDGE2.0 (Available for all computers) — **Price: $17.95 Cassette/$21.95 Diskette**
An all-inclusive version of this most popular of card games. This program both BIDS and PLAYS either contract or duplicate bridge. Depending on the contract, your computer opponents will either play the offense OR defense. If you bid too high, the computer will double your contract! BRIDGE 2.0 provides challenging entertainment for advanced players and is an excellent learning tool for the bridge novice.

HEARTS 1.5 (Available for all computers) — **Price: $14.95 Cassette/$18.95 Diskette**
An exciting and entertaining computer version of this popular card game. Hearts is a trick-oriented game in which the purpose is not to take any hearts or the queen of spades. Play against two computer opponents who are armed with hard-to-beat playing strategies.

CRIBBAGE (TRS-80 only) — **Price: $14.95 Cassette/$18.95 Diskette**
This is simply the best cribbage game available. It is an excellent program for the cribbage player in search of a worthyopponent as well as for the novice wishing to improve his game. The graphics are superb and assembly language routines provide rapid execution.

STUD POKER (ATARI only) — **Price: $11.95 Cassette/$15.95 Diskette**
This is the classic gambler's card game. The computer deals the cards one at a time and you (and the computer) bet on what you see. The computer does not cheat and *usually* bets the odds. However, it sometimes bluffs! Also included is a five card draw poker betting practice program. This package will run on a 16K ATARI. Color, graphics, sound.

POKER PARTY (Available for all computers) — **Price: $17.95 Cassette/$21.95 Diskette**
POKER PARTY is a draw poker simulation based on the book, POKER, by Oswald Jacoby. This is the most comprehensive version available for microcomputers. The party consists of yourself and six other (computer) players. Each of these players (you will get to know them) has a different personality in the form of a varying propensity to bluff or fold under pressure. Practice with POKER PARTY before going to that expensive game tonight! Apple Cassette and diskette versions require a 32 K (or larger) Apple II.

NOMINOES JIGSAW (Atari, Apple and TRS-80 only) — **Price: $16.95 Cassette/$20.95 Diskette**
A jigsaw puzzle on your computer! Complete the puzzle by selecting your pieces from a table consisting of 60 different shapes. NOMINOES JIGSAW is a virtuoso programmingeffort. The graphics are superlative and the puzzle will challenge you with its three levels of difficulty. Scoring is based upon the number of guesses taken and by the difficulty of the board set-up.

CRANSTON MANOR ADVENTURE (North Star only) — **Price: $19.95**
At last! A comprehensive Adventure game for the North Star. CRANSTON MANOR ADVENTURE takes you in mysterious CRANSTON MANOR where you attempt to gather fabulous treasures. Lurking in the manor are wild animals and robots who will not give up the treasures without a fight. The number of rooms is greater and the associated descriptions are much more elaborate than the current popular series of Adventure programs, making this game the top in its class. Play can be stopped at any time and the status stored on diskette. Requires 32K.

VALDEZ (Available for all computers) — **Price: $14.95 Cassette/$18.95 Diskette**
A simulation of supertanker navigation in the Prince William Sound and Valdez Narrows. The program uses an extensive 256X256 element radar map and employs physical models of ship response and tidal patterns. Chart your own course through ship and iceberg traffic. Any standard terminal may be used for display.

FLIGHT SIMULATOR (Available for all computers) — **Price: $17.95 Cassette/$21.95 Diskette**
A realistic and extensive mathematical simulation of take-off, flight and landing. The program utilizes aerodynamic equations and the characteristics of a real airfoil. You can practice instrument approaches and navigation using radials and compass headings. The more advanced flyer can also perform loops, half-rolls and similar aerobatic maneuvers.

STARTREK 3.2 (Available for all computers) — **Price: $ 9.95 Cassette/$13.95 Diskette**
This is the classic Startrek simulation, but with several new features. For example, the Klingons now shoot at the Enterprise without warning while also attacking starbases in other quadrants. The Klingons also attack with both light and heavy cruisers and move when shot at! The situation is hectic when the Enterprise is besieged by three heavy cruisers and a starbase S.O.S. is received! The Klingons get even!

CHESS MASTER (North Star and TRS-80 only) — **Price: $19.95 Cassette/$23.95 Diskette**
This complete and very powerful program provides five levels of play. It includes castling, en passant captures and the promotion of pawns. Additionally, the board may be preset before the start of play, permitting the examination of "book" plays. To maximize execution speed, the program is written in assembly language (by SOFTWARE SPECIALISTS of California). Full graphics are employed in the TRS-80 version, and two widths of alphanumeric display are provided to accommodate North Star users.

BLACK HOLE (Apple only) — **Price: $14.95 Cassette/$18.95 Diskette**
This is an exciting graphical simulation of the problems involved in closely observing a black hole with a space probe. The object is to enter and maintain, for a prescribed time, an orbit close to a small black hole. This is to be achieved without coming so near the anomaly that the tidal stress destroys the probe. Control of the craft is realistically simulated using side jets for rotation and main thrusters for acceleration. This program employs Hi-Res graphics and is educational as well as challenging.

HODGE PODGE (Apple only, 48K Integer BASIC) — **Price: $19.95 Cassette/$23.95 Diskette**
Let HODGE PODGE be your child's baby sitter. Pressing any key on your Apple will result in a different and intriguing "happening" related to the letter or number of the chosen key. The program's graphics, color and sound are a delight for children from ages 1½ to 9. HODGE PODGE is a non-intimidating teaching device which brings a new dimension to the use of computers in education. HODGE PODGE requires a 48K Apple running with Integer BASIC.

TEACHER'S PET I (Available for all computers) — **Price: $ 9.95 Cassette/$13.95 Diskette**
This is the first of DYNACOMP's educational packages. Primarily intended for pre-school to grade 3, TEACHER'S PET provides the young student with counting practice, letter-word recognition and three levels of math skill exercises.

SPACE TILT (Apple only) — **Price: $10.95 Cassette/$14.95 Diskette**
Use the game paddles to tilt the plane of the TV screen to "roll" a ball into a hole in the screen. Sound simple? Not when the hole gets smaller and smaller! A built-in timer allows you to measure your skill against others in this habit-forming action game.

MOVING MAZE (Apple only) — **Price: $10.95 Cassette/$14.95 Diskette**
MOVING MAZE employs the games paddles to direct a puck from one side of a maze to the other. However, the maze is dynamically (and randomly) built and is continually being modified. The objective is to cross the maze without touching (or being hit by) a wall. Scoring is by an elapsed time indicator, and three levels of play are provided.

ALPHA FIGHTER (Atari only) — **Price: $14.95 Cassette/$18.95 Diskette**
Two excellent graphics and action programs in one! ALPHA FIGHTER requires you to destroy the alien starships passing through your sector of the galaxy. ALPHA BASE is in the path of an alien UFO invasion; let five UFO's get by and the game ends. Both games require the joystick and get progressively more difficult the higher you score!

INTRUDER ALERT (Atari only) — **Price: $16.95 Cassette/$20.95 Diskette**
This is a fast paced graphics game which places you in the middle of the "Dreadstar" having just stolen its plans. The droids have been alerted and are directed to destroy you at all costs. You must find and enter your ship to escape with the plans. Five levels of difficulty are provided. INTRUDER ALERT requires a joystick and will run on 16K systems.

GIANT SLALOM (Atari only) — **Price: $14.95 Cassette/$18.95 Diskette**
This real-time action game is guaranteed addictive! Use the joystick to control your path through slalom courses consisting of both open and closed gates. Choose from different levels of difficulty, race against other players or simply take practice runs against the clock. GIANT SLALOM will run on 16K systems.

CRYSTALS (ATARI only) — **Price: $ 9.95 Cassette/$13.95 Diskette**
A unique algorithm randomly produces fascinating graphics displays accompanied with tones which vary as the patterns are built. No two patterns are the same, and the combined effect of the sound and graphics are mesmerizing. CRYSTALS has been used in local stores to demonstrate the sound and color features of the Atari.

CHOMP-OTHELLO (Atari only) — **Price: $11.95 Cassette/$15.95 Diskette**
CHOMP-OTHELLO? It's really two challenging games in one. CHOMP is similar in concept to NIM; you must bite off part of a cookie, but avoid taking the poisoned portion. OTHELLO is the popular board game set to fully utilize the Atari's graphics capability. It is also very hard to beat! This package will run on a 16K system.

GAMES PACK I (Available for all computers) — **Price: $9.95 Cassette/$13.95 Diskette**
GAMES PACK I contains the classic computer games of BLACKJACK, LUNAR LANDER, CRAPS, HORSERACE, SWITCH and more. These games have been combined into one large program for ease in loading. They are individually accessed by a convenient menu.

GAMES PACK II (Available for all computers) — **Price: $9.95 Cassette/$13.95 Diskette**
GAMES PACK II includes the games CRAZY EIGHTS, JOTTO, ACEY-DUCEY, LIFE, WUMPUS and others. As with GAMES PACK I, all the games are loaded as one program and are called from a menu.

Why pay $7.95 or more per program when you can buy a DYNACOMP collection for just $9.95?

NORTH STAR SOFTWARE EXCHANGE (NSSE) LIBRARY — **Price $9.95 Diskette**
DYNACOMP now distributes the 20 - volume NSSE library. Most of these diskettes offer an outstanding value for the purchase price. Write for details regarding the contents of this library and quantity (four or more) purchases.

Availability

DYNACOMP software is supplied with complete documentation containing clear explanations and examples. Unless otherwise specified, all programs will run within 16K program memory space (ATARI requires 24K). Except where noted, programs are available on ATARI, PET, TRS-80 (Level II) and Apple (Applesoft) cassette and diskette as well as North Star single density (double density compatible) diskette. Additionally, most programs can be obtained on standard (IBM format) 8" CP/M floppy disks for systems running under MBASIC.

BUSINESS and UTILITIES

MAIL LIST 2.2 (Apple, Atari and North Star diskette only) — **Price: $34.95**
This program is unmatched in its ability to store a maximum number of addresses on one diskette (minimum of 1100 per diskette, more than 2200 for "double density" systems!). Its many features include alphabetic and zip code sorting, label printing, merging of files and a unique keyword seeking routine which retrieves entries by a virtually limitless selection of userdefined codes. A very valuable program!

FORM LETTER SYSTEM (FLS) (Apple and North Star diskette only) — **Price: $21.95**
Use FLS to create and edit form letters and address lists. Form letters are produced by automatically inserting each address into a predetermined portion of your letter. FLS is completely compatible with MAIL LIST 2.2, which may be used to manage your address files.

FLS and MAIL LIST 2.2 are available as a combined package for $49.95.

PERSONAL FINANCE SYSTEM (ATARI only) — **Price: $34.95 Diskette**
PFS is a single disk menu oriented system composed of 10 programs designed to organize and simplify your personal finances. Features include a 300 transaction capacity; fast access; 26 optional user codes; data retrieval by month, code or payee; optional printing of reports; checkbook balancing; bar graph plotting and more. Also provides on the diskette is ATARI DOS 2.

FINDIT (North Star only) — **Price: $19.95**
This is a three-in-one program which maintains information accessible by keywords of three types: Personal (eg: last name), Commercial (eg: plumbers) and Reference (eg: magazine articles, record albums, etc). In addition to keyword searches, there are birthday, anniversary and appointment searches for the personal records and appointment searches for the commercial records. Reference records are accessed by a single keyword or by cross-referencing two or three keywords.

DFILE (North Star only) — **Price: $19.95**
This handy program allows North Star users to maintain a specialized data base of all files and programs in the stack of disks which invariably accumulates. DFILE is easy to set up and use. It will organize your disks to provide efficient locating of the desired file or program.

GRAFIX (TRS-80 only) — **Price: $12.95 Cassette/$16.95 Diskette**
This unique program allows you to easily create graphics directly from the keyboard. You "draw" your figure using the program's extensive cursor controls. Once the figure is made, it is automatically appended to your BASIC program as a string variable. Draw a "happy face", call it H$ and then print it from your program using PRINT H$! This is a very easy way to create and save graphics.

TIDY (TRS-80 only) — **Price: $10.95 Cassette/$14.95 Diskette**
TIDY is an assembly language program which allows you to renumber the lines in your BASIC programs. TIDY also removes unnecessary spaces and REMark statements. The result is a compacted BASIC program which uses much less memory space and executes significantly faster. Once loaded, TIDY remains in memory; you may load any number of BASIC programs without having to reload TIDY!

STATISTICS and ENGINEERING

DATA SMOOTHER (Not available for ATARI) — **Price: $14.95 Cassette/$18.95 Diskette**
This special data smoothing program may be used to rapidly derive useful information from noisy business and engineering data which are equally spaced. The software features choice in degree and range of fit, as well as smoothed first and second derivative calculation. Also included is automatic plotting of the input data and smoothed results.

FOURIER ANALYZER (Available for all computers) — **Price: $14.95 Cassette/$18.95 Diskette**
Use this program to examine the frequency spectra of limited duration signals. The program features automatic scaling and plotting of the input data and results. Practical applications include the analysis of complicated patterns in such fields as electronics, communications and business.

TFA (Transfer Function Analyzer) — **Price: $19.95 Cassette/$23.95 Diskette**
This is a special software package which may be used to evaluate the transfer functions of systems such as hi-fi amplifiers and filters by examining their response to pulsed inputs. TFA is a major modification of FOURIER ANALYZER and contains an engineering-oriented decibel versus log-frequency plot as well as data editing features. Whereas FOURIER ANALYZER is designed for educational and scientific use, TFA is an engineering tool. Available for all computers.

HARMONIC ANALYZER (Available for all computers) — **Price: $24.95 Cassette/$28.95 Diskette**
HARMONIC ANALYZER was designed for the spectrum analysis of repetitive waveforms. Features include data file generation, editing and storage/retrieval as well as data and spectrum plotting. One particularly unique facility is that the input data need not be equally spaced or in order. The original data is sorted and a cubic spline interpolation is used to create the data file required by the FFT algorithm.

FOURIER ANALYZER, TFA and HARMONIC ANALYZER may be purchased together for a combined price of $44.95 (three cassettes) and $56.95 (three diskettes).

REGRESSION I (Available for all computers) — **Price: $19.95 Cassette/$23.95 Diskette**
REGRESSION I is a unique and exceptionally versatile one-dimensional least squares "polynomial" curve fitting program. Features include very high accuracy; an automatic degree determination option; an extensive internal library of fitting functions; data editing; automatic data and curve plotting; a statistical analysis (eg: standard deviation, correlation coefficient, etc.) and much more. In addition, new fits may be tried without reentering the data. REGRESSION I is certainly the cornerstone program in any data analysis software library.

REGRESSION II (PARAFIT) (Available for all computers) — **Price: $19.95 Cassette/$23.95 Diskette**
PARAFIT is designed to handle those cases in which the parameters are imbedded (possibly nonlinearly) in the fitting function. The user simply inserts the functional form, including the parameters (A(1), A(2), etc.) as one or more BASIC statement lines. Data and results may be manipulated and plotted as with REGRESSION I. Use REGRESSION I for polynomial fitting, and PARAFIT for those complicated functions.

MULTILINEAR REGRESSION (MLR) (Available for all computers) — **Price: $24.95 Cassette / $28.95 Diskette**
MLR is a professional software package for analyzing data sets containing two or more linearly independent variables. Besides performing the basic regression calculation, this program also provides easy to use data entry, storage, retrieval and editing functions. In addition, the user may interrogate the solution by supplying values for the independent variables. The number of variables and data size is limited only by the available memory.

REGRESSION I, II and MULTILINEAR REGRESSION may be purchased together for $49.95 (three cassettes) or $61.95 (three diskettes).

BASIC SCIENTIFIC SUBROUTINES, Volume I (Not available for ATARI)
DYNACOMP is the exclusive distributor for the software keyed to the text *BASIC Scientific Subroutines, Volume I* by F. Ruckdeschel (see the BYTE/McGraw-Hill advertisement in BYTE magazine, January 1981). These subroutines have been assembled according to chapter. Included with each collection is a menu program which selects and demonstrates each subroutine.

- Collection #1: Chapters 2 and 3: Data and function plotting, complex variables
- Collection #2: Chapter 4: Matrix and vector operations
- Collection #3: Chapters 5 and 6: Random number generators, series approximations

Price per collection: $14.95 Cassette/$18.95 Diskette

All three collections are available for $39.95 (three cassettes) and $49.95 (three diskettes).

Because the text is a vital part of the documentation, *BASIC Scientific Subroutines, Volume I* is available from DYNACOMP for $19.95 plus 75¢ postage and handling.

ROOTS (Available for all computers) — **Price $9.95 Cassette/$13.95 Diskette**
In a nutshell, ROOTS simultaneously determines all the zeroes of a polynomial having real coefficients. There is no limit on the degree of the polynomial, and because the procedure is iterative, the accuracy is generally very good. No initial guesses are required as input, and the calculated roots are substituted back into the polynomial and the residuals displayed.

Ordering Information

All orders are processed and shipped postpaid within 48 hours. Please enclose payment with order along with computer information. If paying by VISA or Master Card, include all numbers on card. For orders outside North America add 10% for shipping and handling.

Add $2.50 to diskette price for 8" floppy disk (IBM format soft sectored, CP/M, Microsoft BASIC)

*TRS-80 diskettes are not supplied with DOS or BASIC.

Deduct 10% when ordering 3 or more programs.

Ask for **DYNACOMP** programs at your local software dealer. Write for detailed descriptions of these and other programs from DYNACOMP.

DYNACOMP, Inc.
1427 Monroe Avenue
Rochester, New York 14618
24 hour mail order phone: (716)586-7579
Office phone (9AM-5PM EST): (716)442-8960





New York State residents please add 7% NYS sales tax.

⁺ *ATARI, PET, APPLE II, TRS-80, NORTH STAR, CP/M and IBM are registered trade names and/or trademarks.*

Circle 126 on inquiry card.

Even more useful (and amazing) is *autolink*. Autolink allows Super-Text to find and replace across an unlimited number of files. This action can occur in forward, backward, or even circular directions. Simply enclose the next file in colon symbols, place it at the end of the file (or the beginning, for a backward or circular link), and set the autolink flag. Any further find or replace command automatically searches the current file, loads the next, and searches it as well. Needless to say, this is a powerful feature that is unavailable on some of the big word processors.

Another feature that is neglected by some of the larger manufacturers is the split-screen mode. It is fascinating to see such a sophisticated feature in a word processor for a microcomputer. However, we wondered about the value of this feature. What can it be used for? In any case, it exists in Super-Text, and if you *can* use it—so much the better. We suspect it has only dazzle value.

In addition to Super-Text's excellent editing, there is a math mode that performs as a four-function calculator for columnar and embedded numerical data. It features an accumulator with up to fifteen-digit significance, and a decimal point that can be set by the operator. This calculator also adds up columns—even across screens. Once sums are in the accumulator, they can be easily inserted in the text, and even automatically aligned on decimal points.

The printouts look clean and professional, which is dependent, in part, on the printer you use. We used a Centronics 737, which is a "smart" (microprocessor-controlled) printer that looks good even though it is a dot-matrix printer. The printer can do many things by itself, and this is where the adaptability of Super-Text becomes a factor. Right justification is performed by space insertion, and it has the appearance of being evenly proportioned since Super-Text seems to place spaces after punctuation first, and then randomly across the line. Super-Text does not perform true proportional spacing, but the Centronics 737 does this automatically with a proportional type font.

The Centronics responds to certain control characters that are sent to it to control particular features, such as underlining, choice of type font, super-/subscripting, and elongation of text (any type font may be printed as double-width characters). While Super-Text cannot directly control these printer functions, it allows six control characters which can be user-defined. (Four of these are configured for Diablo printers.) Some technical knowledge is required to redefine these control characters, but step-by-step instructions lead you through the process.

Although you can add an assembly-language printer driver to Super-Text, it is usually unnecessary. The first time you use Super-Text, you should configure it for your printer; this data is then saved on disk, and you should never again have to change your printer configuration (unless you get a different printer). The formatting parameters given at configuration time can be easily changed within the text.

Super-Text can use continuous form or single-sheet paper. It is difficult, however, to change back and forth, since you must reconfigure the printer every time that you switch. The operator can stop and start a printout at any time by the touch of a key. Page numbers can be suppressed, and made relative to the beginning of a chapter with the insertion of a control character. Page numbers can also be moved around the page for maximum flexibility. There is no provision that automatically locates the proper line for footnotes. The operator must count up lines for proper placement.

Human engineering is a weak point with Super-Text. The program does provide excellent prompts when necessary, including warnings for dangerous commands (eg: "PRESS # TO DELETE→" for deleting the entire text buffer) and multiple keystrokes to avoid accidental deletion. The problem, however, is that a lot of the control characters are not mnemonic. Also, multiple keystrokes for simple operations abound in Super-Text.

Vista

Model V1000

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(This problem can be avoided, as demonstrated by Write-On!, another word processor designed for Apple II.) Some functions can be "undone" by using the escape key, but since most of the action takes place instantly, it is difficult to undo these commands. This is not the fault of Super-Text.

Text can be easily recovered from a "crash." If you find yourself in the Apple II monitor (denoted by an asterisk at the beginning of the line), simply type "3D0G", hit the return key, and then "CALL 4096", followed by the return key. You are placed back in Super-Text! We have yet to enter a file that exceeds the capacity of the text buffer in Super-Text, so we don't know what happens when it fills up. The manual states that the processor will warn you when the buffer is almost filled.

Super-Text appears to use its own disk operating system, but it does use BLOAD and BSAVE to load and save text files. These operations are quick and easy. The fact that Super-Text can't be copied is probably the biggest problem. Perhaps Muse has realized how inconvenient this is, because it has provided two disks of the program. We understand its reluctance to put a copyable program on the market, but we feel that there are other ways to avoid piracy. One solution is to create a disk that can be copied a limited number of times but that produces uncopyable copies. In any event, there is a replacement policy, but there is also a $10 media replacement charge.

Super-Text documentation comes in the form of an instruction manual. As a teaching tool, this manual is insufficient. The features are explained well, and some are supplemented with examples from the Super-Text disk. However, no quick reference card is provided, and it is sorely needed. The commands summarized at the end of each chapter explain the modes, but this is not enough, since you must leaf through the manual

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until you have memorized all of the commands. There are no listings of the program, but as it can't be modified this makes little difference. In all fairness, the program provides for any modification you might want to make, so listings are unnecessary.

Super-Text is a very good word-processing program, and it generally works very well, especially after the user has adapted to the processor's particular methods. We won't give numerical ratings, as too much depends on the user's needs, but we'll give you a hint. We prepared part of this article with the Super-Text word processor.

Write-On!

Write-On!, like Super-Text, varies little between versions. The additional features of Write-On! II include preset script margins, personalized form letter capabilities using data files, data-file editing and input, and a system for preformatting text files for the printer. Write-On! II can also convert other files into data files.

Write-On! (from Rainbow Computing) is, for the most part, written in BASIC, and it lacks the speed of Super-Text or the Datacope Scribe. Therefore, it is almost a necessity to preformat text files for the printer. Unlike Super-Text, however, the added features are worth the price: in fact, the ability to print personalized form letters justifies the expense.

The following comments apply to both versions of Write-On!, unless otherwise noted.

Write-On! is a *super* word processor, but that name was already taken. Although it lacks some of the flexibility of the other word processors, it provides a full range of commands to process text.

Write-On! supports display of lowercase letters through the use of the Paymar lowercase adapter. It would appear that Mr Paymar and his adapter have become a standard with Apple. [*Paymar had the field to himself for some time, but other companies (particularly Lazer Systems) are also producing lowercase products for the Apple II....*GW] The shift key can be enabled by modifying the keyboard, as mentioned above, but Rainbow Computing does not provide the wire—just the instructions. Without the shift modification, Write-On! uses reverse video and the ESC (escape) key to denote a capital letter. The shift lock is enabled by hitting the ESC key twice.

Write-On! does not support an 80-column board, and since it does its formatting when it prints out, there is no provision for viewing a text file in its final form on the screen. There *is* a feature in Write-On! II that allows print image files to be saved on disk, but the main purpose of these files is

At a Glance

Name
Write-On! I and II

Type
Word processor

Manufacturer
Rainbow Computing
9719 Reseda Blvd
Northridge CA 91324
(213) 349-5560

Price
Write-On! I, $99.95
Write-On! II, $150

Format
5-inch floppy disk

Language
Applesoft BASIC with some 6502 machine-language subroutines

Computer
Apple II or II+ with Language Card or ROM Applesoft, 48 K bytes of memory, and one disk drive

Documentation
67 pages, 22 by 28 cm (8.5 by 11 inches); three-ring binder; Quick Reference Card

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to speed up output to the printer. (The files display gibberish when loaded and viewed on the Apple screen.)

The processor uses the wraparound technique to divide words, so touch typists can enter text quickly and easily. Unfortunately, there is no provision for hyphenation. (This seems to be the rule rather than the exception in word processors for microcomputers.) Write-On! uses control symbols embedded in the text to control tabs, text width, margins, page numbering, text centering, and paragraph indentation. These symbols take the form of "backslash-some characters-backslash" and they are also highlighted on the screen.

Write-On! will accept files not written by itself. Understandably, the process is slower than loading its own files, but the feature does exist. After we tried this command, we found that the files had to be text files in thirteen-sector format. The files that Super-Text saved would not even show up with the CATALOG command because Super-Text uses BLOAD to save its files. The ability to edit previously created text files is an important consideration when you convert from one word processor to another.

Write-On! performs its editing chores with ease and speed. The processor is line-oriented, and although I feel it is more difficult to work with, this is largely a matter of personal preference. An asterisk appears to the left of the line that is currently operating. The replace and find commands are facilitated by machine code, so they are even quicker. Blocks of text can be moved, copied, deleted, or saved easily. Write-On! does not have an autolink command for editing, so you cannot edit across files (as you can with Super-Text) but it does have a merge command similar to that in Datacope's Scribe. Text from a disk file can be inserted anywhere in the text that you are currently editing. Overall, the editing commands are easy to learn and use.

The standard Apple DOS (disk operating system) is used. However, text files are loaded and saved using BLOAD and BSAVE, which reduces waiting time considerably. The saving and loading commands are clear and understandable, and have prompts that lead the user through the process. If you are a programmer, you can modify this function quite easily, because Write-On! is completely modifiable and copyable. There are some machine-language subroutines for *find* and *replace* functions, but those subroutines work well so there is little need to change them. The program runs in 48 K-byte machines only, but there is adequate room for lengthy files. The manual doesn't tell you what happens if the text buffer fills up, but we never encountered that problem.

There does appear to be a problem where output is concerned: there is no provision for a machine-language driver (sometimes used to drive a nonstandard printer). When initially configured, Write-On! only asks what slot your printer is in. In addi-

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Set Page Length to n
Set Right Margin to n
Dump Text Screen to Printer
Don't Output High Bit
Change to New Command Character
Change Back to Command Character
Turn off Video, Set Line Length to n

GRAPHICS COMMANDS

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Output Hi-Res Page 2
Output Hi-Res Page 1 Inverse
Output Hi-Res Page 1 Rotated 9O °
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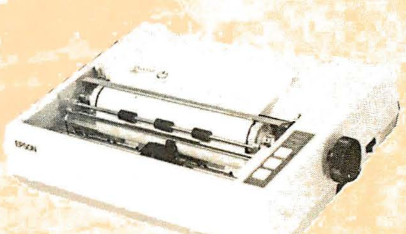


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tion, it is not very adaptable to particular features of different printers. Although Write-On! has several features such as underlining and boldface, it needs some user-defined control characters because it does not provide for such conditions as different type fonts, super-/subscripting, different color ribbons, or proportional spacing. It *will* justify to the right margin, and it does a good job of it. The text doesn't look thin in any particular spot.

Write-On! changes easily from sheet to continuous form. Page numbers can be moved to any position on the page, and numbering can be suppressed. While we were investigating page numbering, we encountered a mystery: Write-On! only allows an absolute page number, yet the manual, which was written with Write-On!, has chapter-relative page numbers (eg: 3 - 4). It seems there is a command that allows a string to be printed to the left or the right of the page number. The chapter must have been inserted as that string and then changed at the beginning of every chapter. This is still mysterious, however, because the manual makes no mention of it. (Except for the EasyWriter Professional word processor, none of these word processors have provisions for footnoting, and Write-On! is no exception.) Write-On! also provides predefined titles. You can define up to twenty titles, which will appear at the beginning of each page.

Write-On! II even provides for form letters using data files. You can build a file of personal or company names, or addresses, and then insert them into a form letter upon printout. This is a tremendously powerful and useful feature (especially for the price). As if this is not enough, Rainbow includes a data-file converter program that takes files from mailing lists and general ledgers and automatically converts them to the proper data-file format. If you want to insert data while your text is printing, Write-On! will accept input from the keyboard and print it where you have embedded the special control character. It even provides for a string that will print on the screen to prompt for the proper information. These are undoubtedly the most powerful features found in a microcomputer-based word processor.

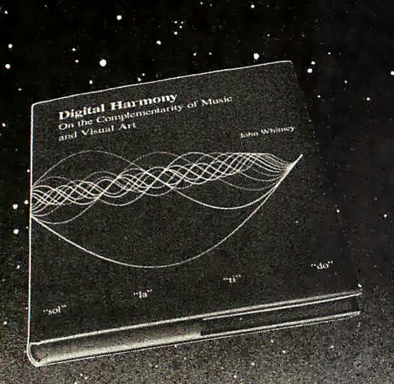
The human engineering in Write-On! is superb. All of the commands are mnemonic and provoke little confusion. Most of the commands use only one keystroke, thus simplifying matters even further. Although the print module is separate from the editor program, its use is simplified by prompts and a menu selection. All of the editing and printing commands are prompted, and error traps are included so that it is difficult to inadvertently destroy several hours of typing.

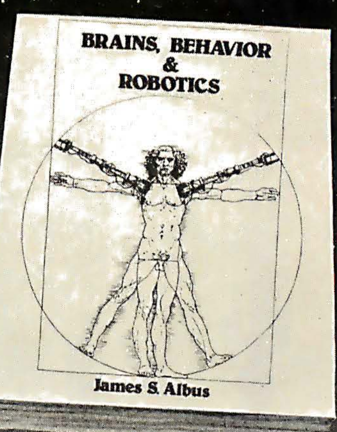
Along with the excellent human engineering, Write-On! provides superlative documentation. This documentation leads the user by the hand; explanations of the various features are clear and concise, and even the complex operations make sense the

Text continued on page 196

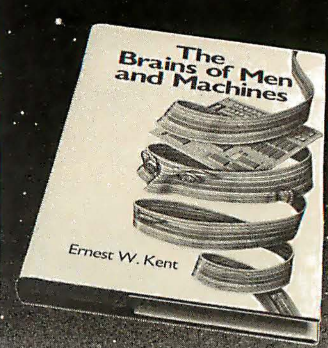


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John Whitney is on the Faculty in the Department of Art at the University of California, Los Angeles.

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Scott Kim is a doctoral student in Computer Science at Stanford University and is a concert pianist and composer.

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Dr. James S. Albus is Project Manager with the National Bureau of Standards.

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Dr. Ernest W. Kent is a Professor of Physiological Psychology and Psychopharmacology at the University of Illinois at the Chicago Circle Campus.

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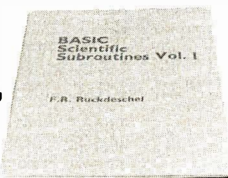
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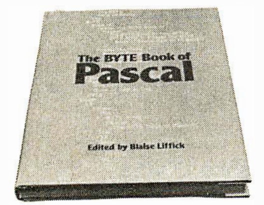
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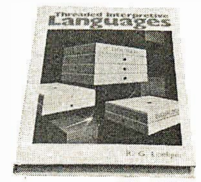
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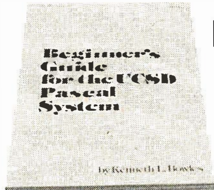
Ron Loeliger is a Senior Analyst with Intermetrics, Inc.

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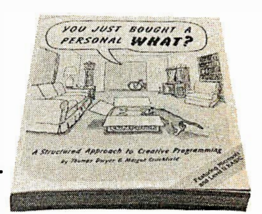
Dr. Kenneth L. Bowles is Director of the Institute for Information Systems, University of California, San Diego.

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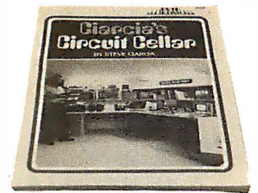
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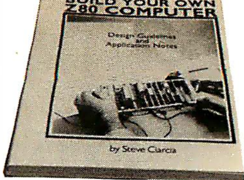
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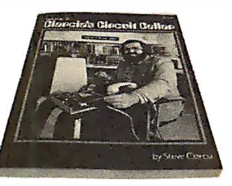
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Steve Ciarcia is a Computer Consultant, Electrical Engineer, and author of "Ask Byte" and "Ciarcia's Circuit Cellar" columns in BYTE magazine.

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Text continued from page 190:
first time. Examples, both in the manual and in text-file form on the reverse side of the disk, accompany the tutorial narrative. Finally, there is a quick reference sheet near the back of the manual that explains every command (our version is on 14- by 11-inch printout paper, but Rainbow plans to reduce it to an 8½- by 11-inch card).

The manual also includes a question and answer sheet that tries to anticipate any problems, and a reader service card on which you can describe any problem not covered by the question and answer sheet and send to Rainbow for an answer. If you'd rather not wait for the return of the reader service card, you can call Rainbow, and they will try to solve your problem over the phone. No listings of the program are provided, but this is unnecessary as you can load and list it yourself. The program is not a marvel of documented programming, but then BASIC is not known for its accessibility.

Write-On! is amazingly error-free, and it ran the first time we put it on the computer. It can also be easily converted to the new 16-sector format. One of us thinks that Write-On! is his choice of all the word processors that we reviewed. The only reason we didn't use it to prepare this review is that it won't support all of the features of the Centronics 737, which was the printer we used for our final copy.

The Datacope Scribe

The Datacope Scribe (from Datacope) is the only word processor we reviewed that *requires* the Dan Paymar lowercase adapter (which provides true lowercase and uppercase letters on the monitor's screen). One would hope that use of the adapter would eliminate use of inverse characters. However, this word processor uses inverse characters to indicate the various editing functions, such as centering, underline, or new page or paragraph. All of the word processors we reviewed use inverse characters for various reasons (eg: special character representing new paragraph). Inverse characters and special characters are items that we will have to live with, at least for now. The Datacope Scribe does, however, provide a feature that allows us to view the text without all the special control characters; this will be described later in the review.

The Datacope Scribe utilizes two techniques found in several of the word processors for the Apple II: use of the ESC key for shift and use of Control-A for shift lock. The word processor accommodates touch typists and eliminates the need to worry about margins. Hyphenation is indicated by a hyphen when you execute the "implementation" command (the command that causes the word processor to execute all the other commands you have given it). Scribe then prompts for your approval (press RETURN). If you wish to change the location of the hyphen, press either of the arrow keys until the hyphen is where you want it, then press RETURN.

The Datacope Scribe is the only word processor described that requires the Dan Paymar lowercase adapter.

Tabs are input through the use of control-Y. Each time a control-Y is pressed, an inverse ^ appears on the screen. This prints the next character at the next tab position (as given by the values in the tab position table). The word processor supports line centering, underlining and indentation.

The Datacope Scribe has the ability to specify, during input, locations where keyboard input is desired during printing. This feature is nice for adding personal touches to form letters or addresses to letters. Text files on a disk other than the one being worked on must be appended to the current file (ie: they cannot be inserted into the middle of the file). This requires that you preplan in detail before you enter text.

Editing is accomplished with cursor control and additional support from buffer (text-blocks) movements. The Datacope Scribe includes on-line reference guides that will assist the novice during entry and edit modes. These guides provide information on the various control keys and functions. By using the customize program, these guides may be removed from the word processor to make room for more text.

After the text has been entered and edited, the define mode should be

At a Glance

Name
Datacope Scribe

Type
Word processor

Manufacturer
Datacope
PO Drawer AA
Hillcrest Station
Little Rock AR 72205

Price
$79.95

Format
5-inch floppy disk

Language
6502 machine language

Computer
Apple II or II+ with Language Card or ROM Applesoft; 48 K bytes of memory, and one disk drive

Documentation
34 pages, 22 by 28 cm (8.5 by 11 inches); booklet form, prepunched for three-ring binder

Hardware Required
Dan Paymar lowercase adapter and a printer

Audience
Anyone needing a word-processing system

used to define the main format of the final printed text product. This feature allows you to set several parameters associated with printed output: left and right margin positions, number of lines per page, tab positions, single or double spacing between paragraphs and lines, justified right margin (yes/no), and page numbering (yes/no). Up to eight tab settings are provided. When you finish defining the format, use the implement command to prepare for viewing and/or printing. The view command enters the view mode, which displays the text on the monitor in the final output form. Of course, the view mode is limited by the Apple's 40-column display.

The Datacope Scribe is available in both DOS 3.2 and 3.3 versions, and the DOS 3.2 version will work on a DOS 3.3 Apple if you use the BASICS floppy disk first. The Datacope Scribe cannot be copied with standard copy programs. Should you develop disk problems, the processor can be replaced up to ninety days after purchase, with proof of purchase.

EasyWriter

The EasyWriter and EasyWriter Professional word processors have much in common. Anyone who changes to the Professional version should have little difficulty making the transition. Unlike Super-Text and Write-On!, however, there is a noticeable change between EasyWriter and EasyWriter Professional. EasyWriter uses Apple's 40-column display, while the Professional version uses any one of the three most popular 80-column video cards (M & R Sup'R'Terminal, Videx, or DoubleVision). This difference may be the deciding factor when you decide which version to buy. The serious user, most likely a professional, will probably purchase the video card and EasyWriter Professional and write off the cost as a business investment. The home user, unless she or he already has the video card, will purchase the 40-column version.

Both versions begin by offering a menu of activities. The Professional version begins with the disk commands, whereas the original version displays the menu for the editor. The Professional version has added the ability to append disk files during input, which is not possible with the 40-column EasyWriter. The ability to append "glossary"-type files is just one example of the changes made to EasyWriter between versions. Input is much easier with the Professional version, because the 80-column display uses true uppercase and lowercase characters. The original EasyWriter uses the standard inverse characters for uppercase characters (as do most of the other word processors for the Apple). One nice feature about

At a Glance

Name
EasyWriter and EasyWriter Professional

Type
Word processor

Manufacturer
Information Unlimited Software
281 Arlington Ave
Berkeley CA 94707

Price
EasyWriter, $99.95; EasyWriter Professional, $250

Format
5-inch floppy disk

Language
FORTH (threaded 6502 machine language)

Computer
Apple II or II+ with 48 K bytes of memory and one disk drive

Documentation
50 pages, 15.5 by 23 cm (6 by 9 inches); three-ring binder

Hardware Required
Videx, M & R Sup'R'Terminal, or DoubleVision 80-column board (for Professional system only)

Audience
Anyone needing a word-processing system

★★★

4MHZ, DOUBLE DENSITY, COLOR & B/W GRAPHICS . . THE LNW80 COMPUTER



COMPARE THE FEATURES AND PERFORMANCE

FEATURES	LNW80	PMC-80**	TRS-80* MODEL III
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LEVEL II BASIC INTERP.	YES	YES	LEVEL III BASIC
TRS80 MODEL 1 LEVEL II COMPATIBLE	YES	YES	NO
48K BYTES RAM	YES	YES	YES
CASSETTE BAUD RATE	500/1000	500	500/1500
FLOPPY DISK CONTROLLER	SINGLE/ DOUBLE	SINGLE	SINGLE/ DOUBLE
SERIAL RS232 PORT	YES	YES	YES
PRINTER PORT	YES	YES	YES
REAL TIME CLOCK	YES	YES	YES
24 X 80 CHARACTERS	YES	NO	NO
VIDEO MONITOR	YES	YES	YES
UPPER AND LOWER CASE	YES	OPTIONAL	YES
REVERSE VIDEO	YES	NO	NO
KEYBOARD	63 KEY	53 KEY	53 KEY
NUMERIC KEY PAD	YES	NO	YES
B/W GRAPHICS, 128 X 48	YES	YES	YES
HI-RESOLUTION B/W GRAPHICS, 480 X 192	YES	NO	NO
HI-RESOLUTION COLOR GRAPHICS (NTSC), 128 X 192 IN 8 COLORS	YES	NO	NO
HI-RESOLUTION COLOR GRAPHICS (RGB), 384 X 192 IN 8 COLORS	OPTIONAL	NO	NO
WARRANTY	6 MONTHS	90 DAYS	90 DAYS
TOTAL SYSTEM PRICE	$1,915.00	$1,840.00	$2,187.00
LESS MONITOR AND DISK DRIVE	$1,450.00	$1,375.00	---

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LNW80 Computer w/B&W Monitor & one 5" Drive $1,915.00
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* TRS80 Product of Tandy Corporation.
** PMC Product of Personal Microcomputer, Inc.

LNW80

- BARE PRINTED CIRCUIT BOARD & MANUAL $89.95

The LNW80 - A high-speed color computer totally compatible with the TRS-80*. The LNW80 gives you the edge in satisfying your computation needs in business, scientific and personal computation. With performance of 4 MHz, Z80A CPU, you'll achieve performance of over twice the processing speed of a TRS-80*. This means you'll get the performance that is comparable to the most expensive microcomputer with the compatibility to the world's most popular computer (TRS-80*) resulting in the widest software base.

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. High Resolution Graphics
  . RGB Output - 384 x 192 in 8 Colors
  . NTSC Video or RF MOD - 128 x 192 in 8 Colors
  . Black and White - 480 x 192
. 4 MHz CPU
. 500/1000 Baud Cassette
. Upper and Lower Case
. 16K Bytes RAM, 12K Bytes ROM
. Solder Masked and Silkscreened

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- BARE PRINTED CIRCUIT BOARD AND MANUAL $69.95
WITH GOLD CONNECTORS $84.95

The System Expansion will allow you to expand your LNW80, TRS-80*, or PMC-80** to a complete computer system that is still totally software compatible with the TRS-80* Model 1 Level II.

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. Precision write precompensation circuit
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. LNW80 Transformer LNW80-3 . . . . $18.00
. LNW80 Keyboard cable LNW80-4 . . . . $16.00
. 40 Pin computer to expansion cable $15.00
. System Expansion Transformer $19.00
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this display is that only the letter displayed in inverse is made uppercase.

EasyWriter displays the least amount of extraneous information with the text of all the word processors covered in this review. Shift is accomplished by pressing the ESC key once; twice for shift lock. The Professional version also uses the ESC key, but allows for the wire between the shift key and 16-pin game I/O port (the game paddle connector) for easier use by a touch typist.

The method of ending paragraphs has also been improved. The original EasyWriter uses two shift-Ms, whereas the Professional uses only a return. The original version used one shift-M to end a line. The Professional's reference manual warns the typist to use the return only to start new paragraphs.

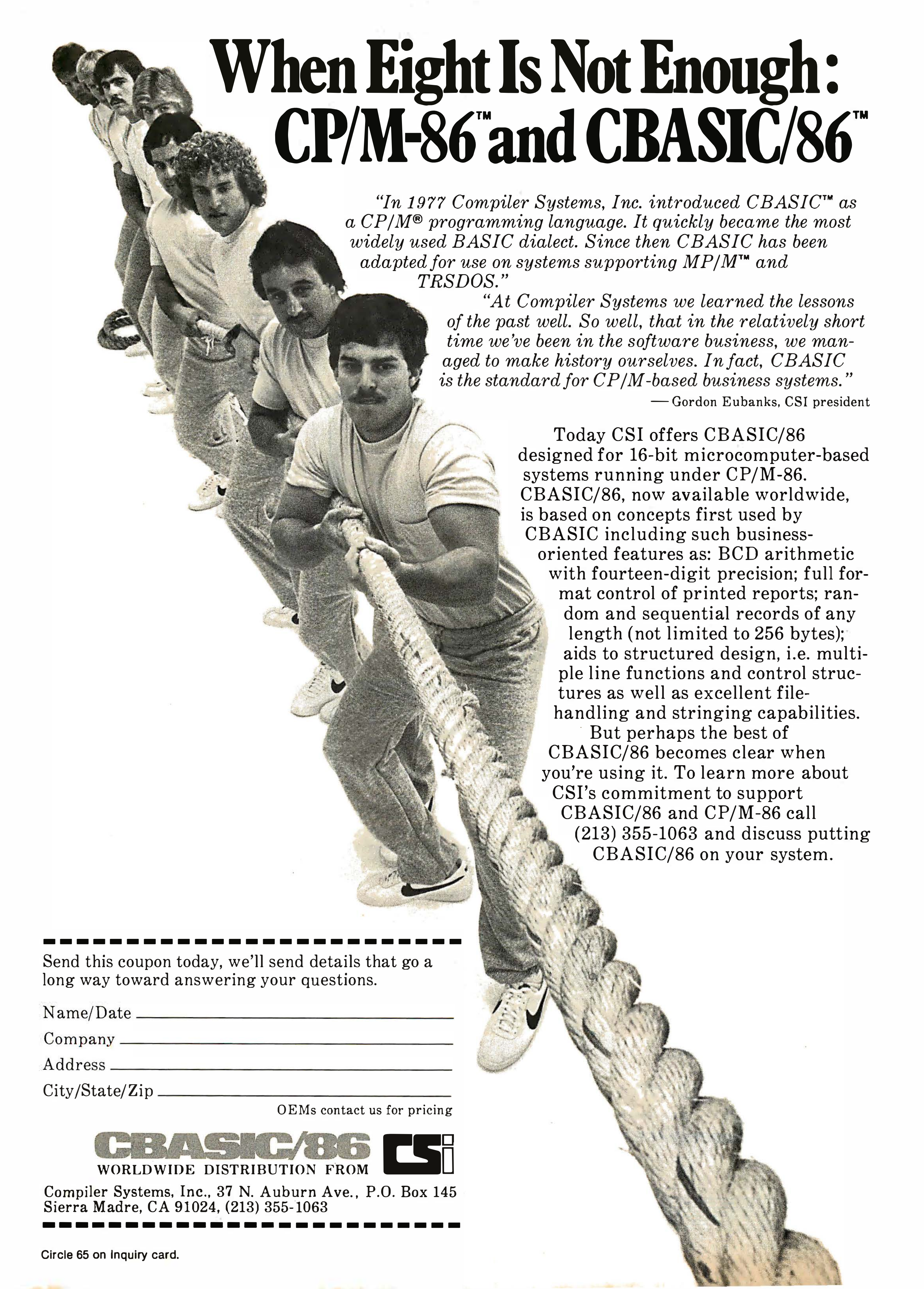
Paragraphs may be formatted to automatically indent through the use of special embedded commands, which are placed between text lines. These commands may appear more than once, thus providing the opportunity to change indentation formats several times in any document. Both versions of EasyWriter support the centering of lines of text, but the method of implementation varies. The original version uses the embedded command technique, while the Professional uses a special editing tool that will be described later.

EasyWriter has the least amount of extraneous information displayed with text.

The 40-column version does not provide a method for viewing the text in final form, but the Professional's 80-column display is the image of the output. And since it is the direct image, an added capability is provided to align text, both after input and prior to printing. Through the use of "additional commands" (which have their own menu screen), the Professional version allows you to realign margins, center lines of text, set and reset tabs, and, for use with printers such as Qume, Diablo, and Spinwriter, vary spacing between letters.

The Professional EasyWriter can translate files from the original 40-column version for use with the 80-column display. Both versions use various control keys to scroll up or down by page or line. Left or right movement on any line is performed with the Apple's normal arrow keys.

Editing is a pleasure with either version. Global search and block movement of text is supported in both versions, but global replace is supported only in the Professional. After you have finished editing, output can be tailored to each document, or you can rely on the default values. The original version accomplishes tailoring with embedded commands; the Professional version uses the additional commands to realign text (as described above), as well as optional


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embedded commands.

The provision for titling and numbering pages is one of the best we have seen for the Apple. The placement of titles and page numbers is limited only by your imagination.

Other advantages specific to EasyWriter Professional are suggestions and instructions for adding footnotes (the only word processor we reviewed that had such suggestions); capability of being linked to EasyMailer for processing of bulk mailings, and ability to transfer EasyWriter files over phone lines to other computers located anywhere in the world. (EasyMover and EasyMailer are separate programs and not part of EasyWriter. They can be obtained from Information Unlimited Software.)

Special printer characteristics are supported by both versions. Those printers that are capable of underlining, boldface printing, and super-/subscripting are conveniently accommodated.

EasyWriter's reference manual was input directly into an Addressograph Multigraph typesetting machine using the proportional spacing option. Even on a printer without proportional spacing, the text spacing is pleasing to the eye.

Many of the EasyWriter features are appealing from the human engineering aspect. Most of the commands on the menu are easy to remember and require only one key to invoke a command. The use of CTRL (control) keys is basically confined to cursor movements during editing.

Before it clears text or deletes files, EasyWriter requests verification: "ARE YOU SURE?" Insert operations can be confusing as to when the insertion mode is exited. (Datacope Scribe has probably done the best job of avoiding confusion on insert operations.)

EasyWriter manuals generally provide good, detailed explanations of the various features. Both manuals attempt to lead the user through the capabilities of the EasyWriter by presenting information that teaches its use and interlacing it with details of the various features.

Program \ Feature	Titles	Global Search and Replace	Merge from Disk	Form Letters with Data Files	User-Defined Control Characters	Displays Lowercase (with adapter)	Requires Use of 80-Column Display Board	Print Multiple Files	Search Across Files	Supports Shift Key (with keyboard modification)	Split Screen	Wild-Card Search	Quick Reference Card	Chapter-Relative Page Numbers	Copyable	Uses Standard DOS	Preview Mode	Footnote
Write-On! I	Y	Y	Y	N	N	Y	N	Y	N	Y	N	N	Y	Y[3]	Y	Y	N	N
Write-On! II	Y	Y	Y	Y	N	Y	N	Y	N	Y	N	N	Y	Y[3]	Y	Y	N	N
Super-Text II	N	Y	N	N	Y	Y	N	Y	Y	Y	Y	Y	N	Y	N	N	Y	N
Scribe	N	N	Y	N	Y	Y[1]	N	N	N	Y	N	N	Y[2]	Y	N	N	Y	N
EasyWriter	Y	N	N	N	Y	N	N	Y	N	N	N	Y	Y	N	Y	Y	N	N
EasyWriter Professional	Y	Y	Y	N	Y	Y	Y	Y	N	Y	N	Y	N	N	N	N	Y[4]	Y

[1]Requires Paymar lowercase adapter
[2]On-line quick reference
[3]Indirectly provided
[4]Print image appears on 80-column screen

Table 1: *Feature comparison of four popular word-processing programs for the Apple II.*

Conclusions

Choosing a word processor is similar to deciding on a microcomputer. Each has special features (see table 1), and none of the products have all the features.

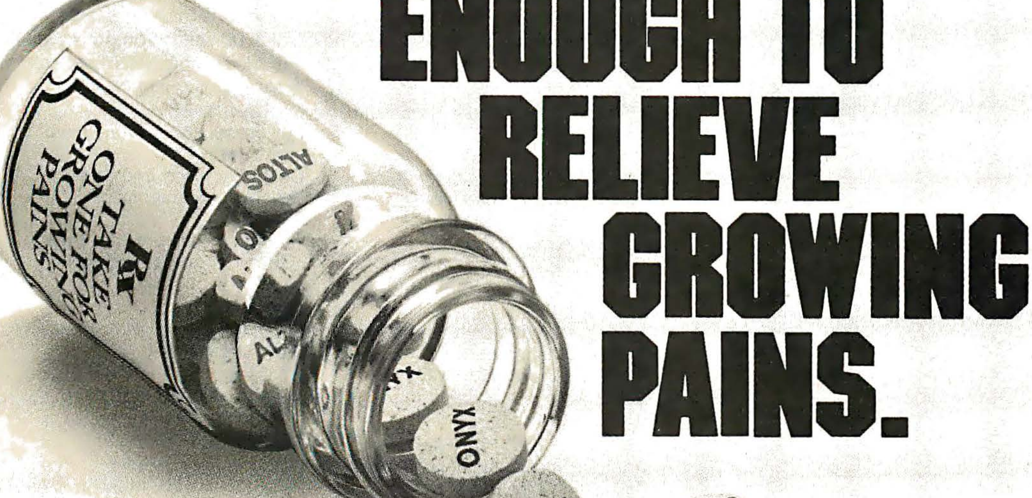
If you want a word processor that performs math operations, the Super-Text II program is for you. If you're looking for a word processor that you can modify, and you know only BASIC, then Write-On! should satisfy your requirements. If you already have one of the 80-column cards, perhaps you should choose the Easy-Writer Professional version. If you are looking for a workhorse processor that will handle bulk mailings, then the EasyWriter Professional linked with EasyMailer is also for you, although Super-Text may meet this demand, and, with some pushing, Write-On! could meet the lower end of these requirements. Datacope Scribe has some very nice features, and if you only wish to process text and can live without a find-and-replace feature, the processor will fulfill your needs.

About this time, you may be thinking, "This is a typical review that says all the products are great." Possibly this is true, but we speak with some experience as we used all of the processors while preparing this article. Each met our needs, and performed basic text processing in less than an hour.

A few years ago, such power in a small package, and at this price, was only a dream. And even today, some of the larger systems don't have equivalent features. ■

Acknowledgments
We would like to acknowledge David A Lingwood for his "Word Processor Guidelines," presented in Call-Apple, *September 1980, page 19.*

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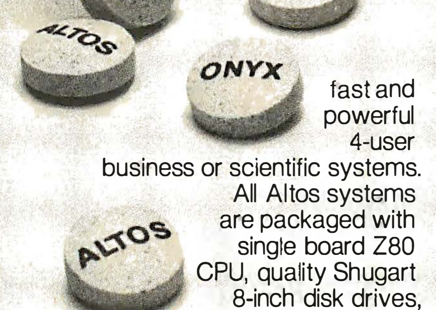
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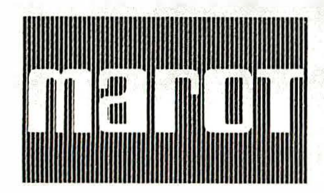
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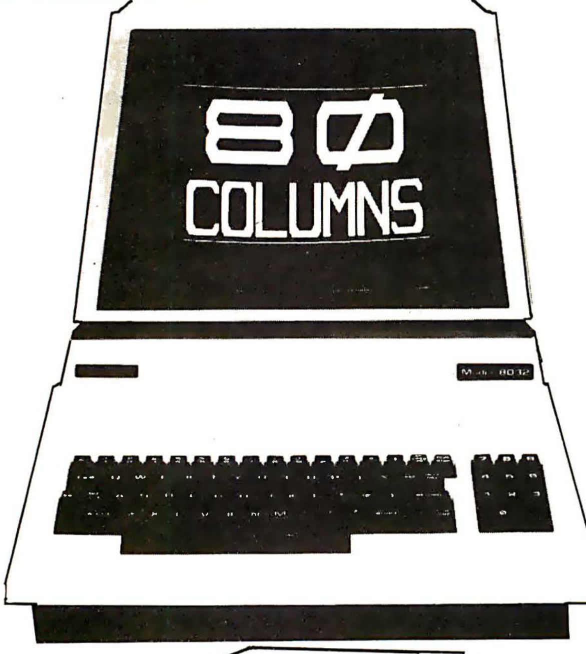
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64 ASCII, 64 graphic characters
3 x 8 dot matrix characters
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Brightness control
Line spacing: 1½ in Text Mode
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KEYBOARD
73-key typewriter style keyboard with graphic capabilities
Repeat key functional with all keys

MEMORY
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CBM 8032: 32K (31743 net) random access memory (RAM)

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Watts: 100

SCREEN EDITING CAPABILITIES
Full cursor control (up, down, right, left)
Character insert and delete
Reverse character fields
Overstriking
Return key sends entire line to CPU regardless of cursor position

INPUT/OUTPUT
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24K or ROM contains:
BASIC (version 4.0) with direct (interactive) and indirect (program) modes
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Tape and disk file handling software

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FIRMWARE
DOS version 2.0
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4040	Dual Floppy-343K-DOS 2.0	$1295.00
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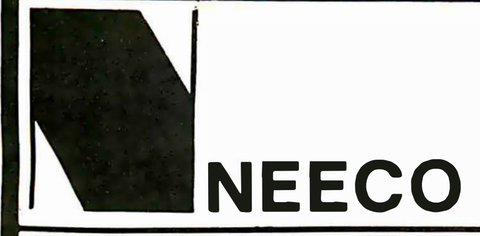
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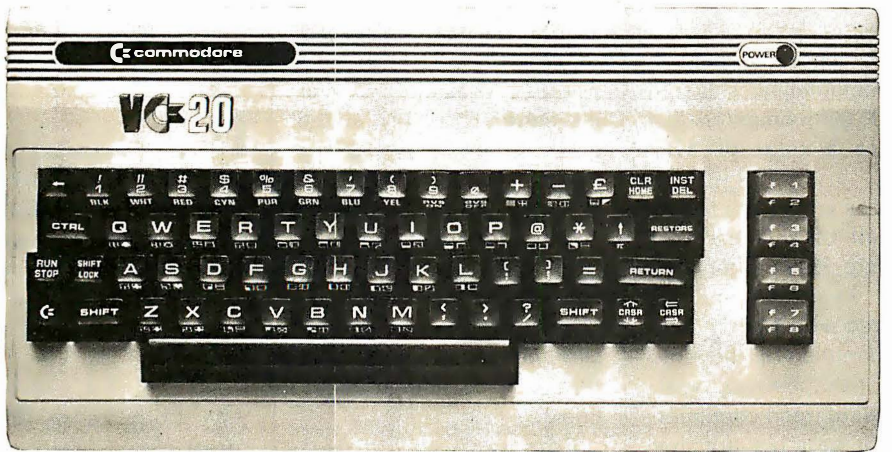


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News and Speculation About Personal Computing

Conducted by Sol Libes

IBM and Matsushita To Join Forces? Matsushita, the giant Japanese electronic conglomerate that markets Panasonic and Quasar products in the US, recently admitted that it had been approached by IBM in regard to manufacturing a personal computer for the US market. It's been rumored for some time that IBM is planning to market a Japanese-made personal computer in the US. Although Matsushita officials released no details regarding their talks with IBM, another report that Matsushita has already designed and built a personal computer has prompted some observers to theorize that the unit will bear the IBM name when it is marketed in the US later this year.

How Are The Personal-Computer Makers Doing? Tandy Corporation, Radio Shack's parent company, continues to have an outstanding growth record. Tandy's sales for the 1979-1980 fiscal year rose to $1.4 billion, up from the previous year's $1.2 billion. Its income has increased 35% since it joined the microcomputer business, which now totals 13% of its overall sales.

This year Tandy expects to add 400 more stores to its fold of nearly 8000. In the US, there will be 250 more stores and 50 computer centers. Tandy plans to open 100 outlets overseas. Foreign sales currently account for 25% of its total sales.

Each Radio Shack store stocks more than 2600 items. The largest portion of a store's sales is parts and accessories (23%), with radios, tape recorders and phonographs second (19%), other audio components third (17%), and toys and microcomputers tied for fourth place (13%). Citizen's Band radios (10%) and telephones (5%) constitute the remaining sales.

Tandy leads the field in microcomputer sales. It sold over 200,000 computers last year for a total of $180 million.

Tandy's gross sales for the final half of calendar year 1980 were $869 million, and profits were $80 million, compared with $739 million and $60 million for the same period the previous year. The upward trend continues: sales this past January shot up to $141 million, from $112 million the year before.

You can still purchase a TRS-80 Model I in England. The Model I was pulled from US shelves in January because it did not comply with the Federal Communications Commission's radio-frequency-interference regulations. Also in England, TRS-80s are sold through independent computer stores as well as through Tandy-owned TRS-80 Computer Centers. So, the same dealer selling Apple IIs and Commodore PETs has TRS-80s on the display shelf. Some dealers also carry the Video Genie EG3000, the Far-Eastern copy of the TRS-80.

Apple Computer Inc also chalked up record sales and income last year. Sales for the last quarter of 1980 were up 246%, and profits were up 180%. The demand for Apple products in the first quarter of 1981 was greater than anticipated, but the company considers it unlikely that this growth will continue into the second quarter of the year.

Apple revealed that the commissions required to sell its stock last year came to $93.3 million, or $1.30 a share. The stock initially sold for $20 to $25 a share; it peaked at a high of $35, and it's currently selling in the neighborhood of $25 a share.

Apple has had problems getting its Apple III computer into production. Announced in May 1980, the first Apple IIIs were not shipped until January 1981, and then only in limited quantities.

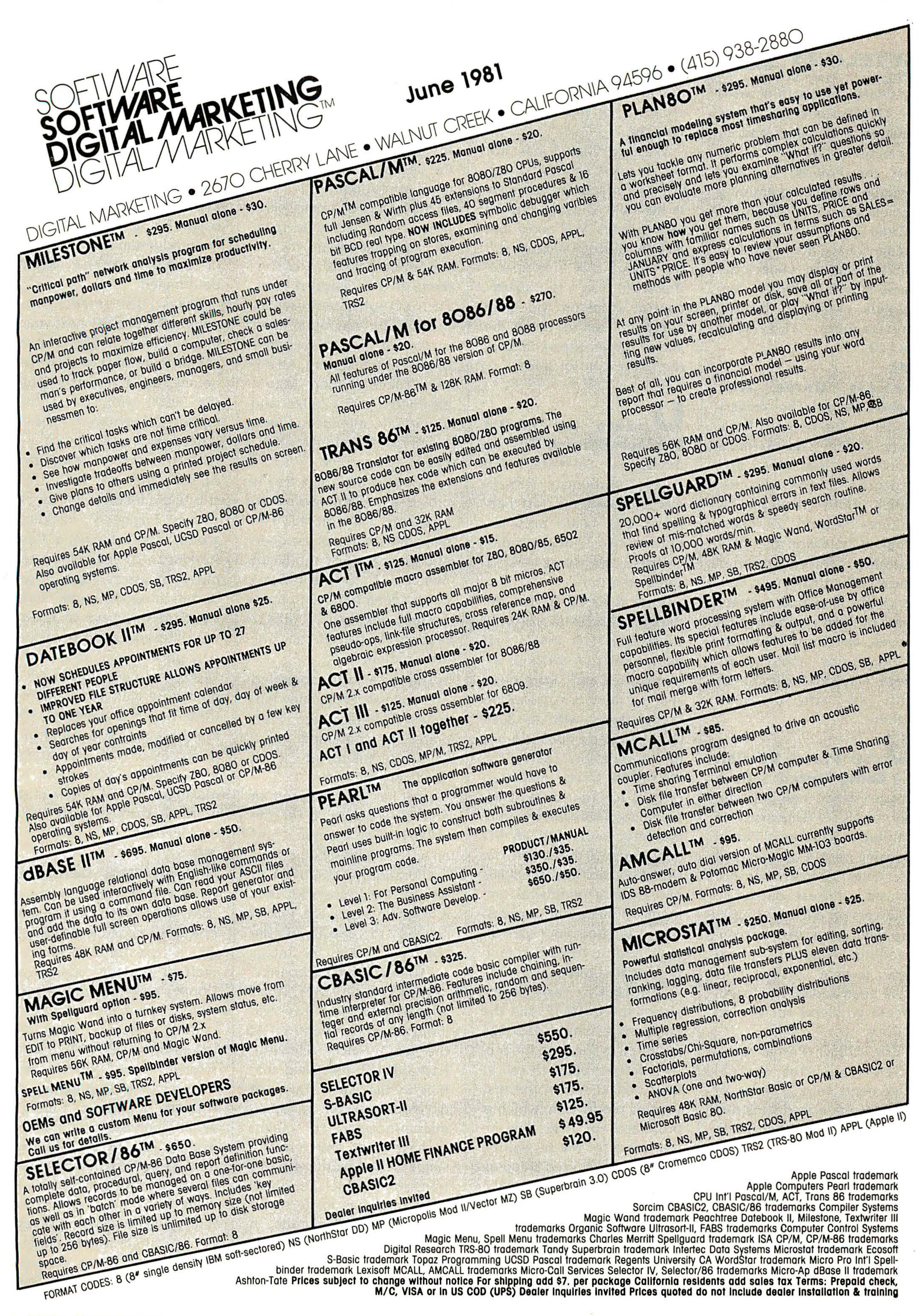
Commodore International's sales for the last quarter of 1980 were $45 million, up from $31 million for the same period in 1979. Commodore has announced plans to construct a $5 million plant in the Philadelphia area to build its microcomputer systems. Commodore expects to hire 250 to 400 people for the operation and open it before year-end.

Sinclair Research, maker of the low-cost ZX80 personal computer, claims that it is number three in units shipped, behind Radio Shack and Apple.

Mattel's keyboard-equipped Intellivision personal-computer system seems to be bumping up against the same sort of buyer resistance that Texas Instruments encountered with its TI 99/4. Consumers are put off by the keyboard unit's $700 list price, plus $300 for the game-playing "master" component—total cost $1000. That's several hundred dollars more than the TRS-80 Color Computer, the Commodore VIC, and even Texas Instruments' TI-99/4. Further, Mattel has had delivery problems: it had originally intended to introduce the system in 1979. Intellivision's marketing is mainly through department stores.

First Personal Computer With Built-In Winchester-Disk Drive: Vector Graphic Inc has unveiled the first personal-computer system with a built-in Winchester-type hard-disk drive. The Model 3005 houses a video monitor, keyboard, S-100 motherboard, Z80 processor, 64 K bytes of programmable memory, a video interface called Flashwriter, a dual-mode disk controller, a Seagate Technology 5-inch Winchester drive, and up to three quad-density 5-inch floppy-disk drives. The system with one floppy-disk drive costs $7950.

Tandy Files Suit Against Competitor: Tandy Corporation has brought suit against Personal Microcomputers Inc (PMC), Mountain View, California. Tandy accuses PMC of conspiracy and infringement on the design of the Radio Shack TRS-80 personal computer. Included in the suit are five manufacturers and dealers for Personal Microcomputers' PMC-80 personal computer. The PMC-80 is hardware- and



Circle 115 on inquiry card.

software-compatible with the TRS-80 Model I. Tandy is demanding damages and an injunction. Tandy claims that the PMC-80 contains "input/output programming copied from the plaintiff's TRS-80," and that the "defendants have marketed said microcomputer under the name PCM-80, which is confusingly similar to Tandy's registered trademark TRS-80."

Chess Game Has Robot Arm: The newest model of the popular Boris computer chess game has a robotic arm that moves and captures chess pieces. Called "Boris Handroid," it features the Boris 2.5 chess program that won the 1979 European Microcomputer Chess Championship. Sensors in the chessboard detect the human opponent's moves, and Boris Handroid responds by moving its piece. The game costs $1495 with the arm or $295 without.

UCSD Pascal Version 4.0 Being Tested: Softech Microsystems' new 4.0 version of UCSD (University of California, San Diego) Pascal is being tested at selected user sites. Softech has not yet set a release date. The new version adds multitasking and upgraded screen-handling functions. Four new p-code instructions have been added, which will create problems for version 3 users.

The UCSD Pascal compiler translates Pascal statements into a series of p-code (pseudocode) instructions, which are then interpreted during execution by a p-code-interpreter program, except on the Western Digital (WD) Pascal Microengine, which executes p-codes according to hardware microcode. The p-code system allows the UCSD Pascal system to operate the same way on many different systems.

Western Digital has not yet decided on how it will upgrade machines currently in the field to work with the new p-codes. WD notes that its control-store memory still has about 25% free space; therefore, an "outboard" control store on the main computer board could be added, rather than changing the entire control store.

Update On 32-Bit Microprocessors: The International Solid-State Circuits Conference (ISSCC) met in New York last February and heard presentations on two 32-bit microprocessors and some disclosures on a third.

Intel released further details on its 32-bit iAPX432 processor. It is Intel's first departure from previous architecture and instruction sets, so there is no software compatibility with its 8086 (16-bit) and 8085 (8-bit) microprocessors. Each of the iAPX432's three integrated circuits has four lines of sixteen pins. There are two general processors and an I/O (input/output) processor. The iAPX432 can link to 8086s and existing peripheral and memory integrated circuits. Intel is boasting performance of up to 2 MIPS (million instructions per second).

It took five years to engineer the iAPX432, and the company estimates that $25 million was spent on the project. Intel expects to sell at least 10,000 sets in the first year of production, which is projected for 1982. The initial price for the set will be $1500. Intel started shipping evaluation sets in February and is offering a board-level evaluation kit for $4250.

Intel claims that each of the three integrated circuits contains about 200,000 transistors. Two chips operate as a pipeline pair: the 43201 processor, which contains the instruction decoder, and the 43202, which is the microexecution unit. The 43203 is the I/O processor. It provides an interface from the I/O subsystem to the protected-access environment of the central system. Each I/O subsystem uses an 8- or 16-bit microprocessor to control I/O, independent of the central system. An address space of more than 4 gigabytes (4×10^9 bytes) and a virtual memory-address space of a terabyte (10^{12} bytes) is supported.

A protection scheme is provided to limit access to programs. The iAPX432 can perform floating-point operations on 32-, 64-, and 80-bit numbers. Hardware failures can be detected by interconnecting identical iAPX432 processors in a self-checking arrangement.

The system uses compiled Ada code as its machine language. The language interpreter is contained in a 64 K-byte microcode ROM (read-only memory).

Intel has also released an Ada cross-compiler for the iAPX432. The compiler runs on a DEC (Digital Equipment Corporation) VAX-11/780 or an IBM 370. It costs $30,000. A $50,000 hardware link is needed to download the compiled code to Intel's $4250 development board.

With the iAPX432, Intel appears to have a two-year jump on its competition. At the conference, Hewlett-Packard (HP) disclosed that it is in the early stages of development on a 32-bit microprocessor. HP claims to have built and tested a single chip with 450,000 transistors (which is about what Intel has in its set of three integrated circuits). It operates with an 18 MHz clock and is microprogrammed in 9 K 38-bit words in an on-board ROM. HP will have four other peripheral devices: an I/O controller, a memory controller, a 128 K-bit programmable memory, and a 512 K-bit ROM. The device is still being developed and no production commitment or product use has been determined.

Texas Instruments announced that early next year it will unveil a 99000 processor. TI refuses to disclose details, but it appears that the 99000 will have 32-bit addressing without 32-bit processing.

Chairperson Andrew Allison and his IEEE (Institute of Electrical and Electronics Engineers) working group is developing a bus standard to accommodate microprocessors from 8 to 32 bits in word length. The standard will have a 32-bit multiplexed address- and data-path compatible with 32-, 16-, and 8-bit microcomputers. It will allow up to thirty-two bus masters and multitasking via a serial interprocessor link that may use interrupt arbitration. A maximum initial clock rate of more than 10 MHz will be specified.

Floppy-Disk Densities Increasing: Ten years ago, IBM introduced an 8-inch disk drive capable of storing 400 K bytes of data (unformatted) on one side of a floppy disk. Shortly afterwards, double-density encoding schemes that allowed up to 800 K bytes of storage were introduced. Then in 1976, IBM came up with the double-sided drive, which increased data storage up to 1.6 megabytes. That same year Shugart Associates introduced a drive using a 5-inch floppy disk that could store 110 K bytes on a single-sided single-density disk. Later double-density double-sided (DDDS)

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Our **"Big 16"** package promotion went over so well that we decided to come up with something equally potent for 8 bit machines. Whether you're upgrading an existing system or assembling a brand new machine, the **"Big 8"** is ideal - just add terminal, disk drive, enclosure, and printer and you're up and running with one of the fastest, most powerful 8 bit systems around.

This easily upgradable package includes:

- **Disk 1** DMA Disk Controller
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- **CP/M*-80** 2.2 on disk
- **32K** of fast, low power, static RAM

To sweeten the deal, we'll add another 32K of RAM if you order from us or your computer store before August 1, 1981. And if you need an enclosure, **Enclosure 2** (desktop version) is available with this package for only **$795** - giving you even more savings.

Total value of the package: $2712. . .but our special package price gives you the "Big 8" for $1995! Who says CompuPro S-100 speed and reliability can't be cost-competitive with home entertainment computers?

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This state of the art design uses properly implemented DMA **with arbitration,** allowing **Disk 1** to co-exist on the same bus with up to 15 other DMA devices. 24 bit DMA addressing capability allows disk access to a full 16 megabyte memory map.

Disk 1 transfers data independently of CPU speed for efficient operation with older 2 MHz CPUs as well as the new high speed 8086s; handles up to four 8" or 5.25" floppy disk drives (including 96 track high density minifloppies), single or double sided, single or double density (soft sectored); includes BIOS for CP/M-80*, as well as on-board boot for automatic startup and on-board 3 wire serial interface for system initialization; and is compatible with MP/M*, OASIS*, CP/M-80, and CP/M-86.

We weren't going to put out another me-too disk controller. . .and we didn't. Want proof? The manual is available separately for $20.
The CompuPro Disk Controller is here.

COMPUTER ENCLOSURE 2
$825 desk top version, $895 rack mount version

Includes fused, constant voltage power supply (+8V at 25 Amps, +16V at 3 Amps, and -16V at 3 Amps); 20 slot shielded/active terminated motherboard; and rugged all-metal enclosure with AC outlets on rear, heavy-duty line filter, circuit breaker, low noise fan, and reset switch. Rack mount version includes slides for easy pull-out from rack frame.

Also available: COMPUTER ENCLOSURE 1. Same as above, but less power supply and motherboard. $289 desktop, $329 rack mount.

SYSTEM SUPPORT 1
$295 Unkit, $395 A/T, $495 CSC

Includes sockets for 4K of extended address EPROM or RAM (2716 pinout) with one battery backup RAM socket; battery operated month/day/year/time crystal clock with BCD outputs; socket for optional math processor (9511 or 9512); full RS-232 serial port; three 16 bit interval timers; two interrupt controllers; power fail indicator; and comprehensive owner's manual with numerous software examples (**manual** available separately for $20; add **$195** to the above prices for the optional **9512** math processor.)

*LEGAL CORNER: Z80A is a registered trademark of Zilog; PASCAL/M is a trademark of Sorcim; CP/M and MP/M are registered trademarks of Digital Research; OASIS is a trademark of Phase 1.

SOFTWARE

8088/8086 MONITOR-DEBUGGER: Supplied on single sided, single density, soft sectored 8" disk. CP/M* compatible. Great development tool; mnemonics used in debug conform as closely as possible to current CP/M* DDT mnemonics. **$35.**

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S-100 MEMORIES FROM THE MEMORY LEADER

CompuPro memories feature fully static design to eliminate dynamic timing problems, flawless DMA, full conformance to all IEEE 696/S-100 specifications, high speed operation (10 MHz), low power consumption, extensive bypassing, and careful thermal design.

	Unkit	A/T	CSC
8K RAM 2A	$159	$189	$239
16K RAM 14 (extended addressing)	$279	$349	$429
16K RAM 20-16 (extended addressing and bank select)	$319	$399	$479
24K RAM 20-24 (extended addressing and bank select)	$429	$539	$629
32K RAM 20-32 (extended addressing and bank select)	$559	$699	$799
128K RAM 21	price upon request		

NEW! 64K RAM 17. Amazingly low power in a 64K **fully static** RAM board: draws less than 2.0 Watts typical, 4.0 Watts guaranteed max! It's fast, too; no wait states with 6 MHz Z-80* CPUs, or up to 10 MHz with 8086/88 family CPUs. Uses **IEEE** extended addressing protocol; also, user may turn off 2K windows from E000 to FFFF in order to accommodate memory-mapped peripherals/disk controllers. (The **CompuPro** disk controller can use the full 64K since it is not memory-mapped.)$1095 Unkit, $1395 A/T, $1595 CSC. 48K version also available: $1048 A/T, $1198.50 CSC.

HIGH SPEED S-100 CPU BOARDS

CompuPro CPU boards meet all **IEEE** 696/S-100 specifications (including timing). **CPU 8085/88** uses two processors, an 8085 and 8088, to provide both 16 and 8 bit capability with a standard 8 bit bus.

8 Bit **CPU Z** (with Z80A* CPU)................$225 Unkit, $295 A/T (both operate at 4 MHz), $395 CSC (with 6 MHz CPU).

8 Bit **CPU 8085** (5 MHz)...............$325 Unkit, $325 A/T, $425 CSC (6 MHz)

16/8 Bit **CPU 8085/88**..........................$295 Unkit, $425 A/T (both operate at 5 MHz); $525 CSC (with 6 MHz 8085, 6 MHz 8088).

OTHER S-100 BUS PRODUCTS

Interfacer 1 (dual RS-232 serial ports)	$199 Unkit, $249 A/T, $324 CSC
Interfacer 2 (3 parallel + 1 serial port)	$199 Unkit, $249 A/T, $324 CSC
Interfacer 3 - 5 (5 serial ports)	$599 A/T, $699 CSC
Interfacer 3 - 8 (8 serial ports)	$699 A/T, $849 CSC
Spectrum color graphics board	$299 Unkit, $399 A/T, $449 CSC
20 slot motherboard w/ edge connectors	$174 unkit, $214 A/T
12 slot motherboard w/ edge connectors	$129 unkit, $169 A/T
6 slot motherboard w/ edge connectors	$89 unkit, $129 A/T
Memory Manager Board	$59 unkit, $85 A/T, $100 CSC
Active Terminator Board	$34.50 Kit, $59.50 A/T
2708 EPROM Board (2708s not included)	$85 Unkit, $135 A/T, $195 CSC
Mullen Extender Board	$59 Kit, $79 A/T
Mullen Relay/Opto-Isolator Control Board	$129 Kit, $179 A/T

Most **CompuPro** products are available in **Unkit** form, **Assembled/Tested**, or qualified under the high-reliability **Certified System Component** (**CSC**) program (200 hour burn-in, more). Note: Unkits are not intended for novices, as de-bugging may be required due to problems such as IC infant mortality. Factory service is available for Unkits at a flat service charge.

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floppy-disk drives were introduced that could store up to 440 K bytes (unformatted).

Recently, Shugart announced 5-inch drives in which track density was increased from 48 tpi (tracks per inch) to 96 tpi, allowing up to 1 megabyte on a DDDS drive. However, increasing the track density on 8-inch drives is more difficult because the larger disks have deformation problems that result in errors. Drive and disk makers are trying to overcome the problems by changing the disk materials and drive designs. The current objective is to increase track density to 96 or 100 tpi by early next year. It is felt that 200 tpi is feasible with different materials.

Manufacturers are trying to obtain densities of 3 and 6.5 megabytes on 5-inch floppy disks and 5 to 10 megabytes on 8-inch floppies. The 3- and 5-megabyte densities appear to be achievable in the near future; however, reaching 10 megabytes on an 8-inch disk is expected to take longer to achieve.

In the meantime, PerSci Inc has taken the wraps off an 8-inch floppy-disk drive with a storage capacity of 2.5 megabytes. It's the same size as a standard 8-inch drive, but uses four read/write heads to access both sides of two DDDS disks.

IBM To Build Josephson Computer: IBM is going to construct an experimental computer entirely based on exotic Josephson-junction devices. This will be the first of its kind, and IBM hopes to have it up and running in five years. The 5000-circuit processor, with 400 K bits of programmable memory, is expected to have a 2 ns cycle time and will be no larger than 18 by 20 by 41 mm.

Josephson-junction transistors are superconductive and can switch in less than 10 ps (picoseconds). They consume very little power (usually 500 nW) and typically require a +1 V power supply.

Such a computer could be fifty times faster than current high-speed computers. Engineers have hypothesized that a Josephson-junction-based computer could have a nonvolatile solid-state magnetic memory, and, because of the greatly reduced resistance within its super-cool liquid-helium immersion, thin connectors could be used. Additional attributes could include no crosstalk between devices and immunity to thermal noise. Problems are anticipated in testing and debugging because of the thermal stresses placed on the devices.

If the project is successful, IBM expects to pack a 300,000-circuit processor (about the capacity of an IBM 3033) with 256 K bytes of cache memory and 64 megabytes of main memory into a cube less than 15 cm on a side.

Random Rumors: DEC (Digital Equipment Corporation) is working on a personal computer designed to compete with the Apple III. It's expected to be introduced by year's end. Word is that DEC tried to buy Apple some time ago but was snubbed. . . . Observers expect Apple to introduce a dual-density dual-sided disk system with 600 K bytes of storage for the Apple II and III. You can expect a 5-inch Winchester disk drive with 5-megabyte capacity to hit the shelves by late summer. Apple is considering dropping the present version of the Apple III in favor of a new model that's more business-oriented. The new model will probably contain a hard-disk drive instead of a floppy-disk drive. Apple is scheming an upgraded Apple II with a faster microprocessor and expanded memory size. . . . The Source timesharing system is preparing to sell a low-cost ($600) terminal with built-in modem and printer port; it has a folding keyboard for portability. . . . Texas Instruments is about to introduce a small low-cost robot arm. . . . Hewlett-Packard is preparing an under-$2000 system, maybe for this year. . . . ADDS (Applied Digital Data Systems) says that it will soon introduce a dumb terminal priced one-third less than current models. . . .

Random News Bits: Zenith Radio Corporation has a special video display for automobile dashboards. . . . RCA has received a patent for a technique that stores up to 100 gigabits (ie: 100 billion bits) on a laser disk intended for video. A complete encyclopedia can be stored on such a disk. . . . Sears Roebuck will open five computer stores. If they are successful, Sears Roebuck will sell computers nationwide. . . . Marker Ski Bindings has a binding with a built-in microprocessor. The battery-powered unit costs $200 and must be custom programmed for the skier. . . . Ohio Scientific's new Challenger 8P-HD personal computer has a Votrax voice-synthesizer output system and a voice-input system. It requires a 10-megabyte Winchester disk to function. . . . The Votrax SC-01 Voice Synthesizer Chip is now available from The MicroMint of Woodmere, New York. The Vodex division of Votrax will not sell the device in quantities of less than five. . . . Zilog has reduced the price of the 16-bit Z8002 microprocessor from $45 to $19.90, in OEM quantities of 1000. . . . Intel may reduce its prices for the 8088 and 8086. . . . IBM has a 32-bit microprocessor up and running in its labs. . . . Apple recently purchased its distributor in Great Britain, and now has well over 1000 employees. . . .

Miniaturization Continues: Semiconductor manufacturers keep on packing more capability onto a single wafer of silicon. Intelligent controllers, especially, are benefitting from such efforts. Two of the most recent products are the National Semiconductor INS8073 and the Zilog Z8 system. The Zilog product line includes a microprocessor, designated Z8671, which contains a limited-BASIC interpreter and debugging monitor in on-board read-only memory. Steve Ciarcia is using the Z8671 to build a complete computer system measuring 4 by 4½ inches with serial and parallel I/O ports and 4 K bytes of user memory. Users can program process-control and monitoring functions using the BASIC interpreter. (See next month's "Ciarcia's Circuit Cellar.")

Know Your Dealer: Sources at Radio Shack report the company has been receiving a large number of complaints because of confusion over warranty service on TRS-80s. The problem stems from the fact that Radio Shack does *not* honor warranties on computers purchased from dealers who are not authorized by Radio Shack. A large number of unauthorized dealers have appeared in the past year—most offering extremely low mail-order

prices on TRS-80 systems.

A Radio Shack spokesman said the company is attempting to close the pipeline to unauthorized dealers but declined comment on how the dealers are obtaining the equipment. He stressed that the majority of mail-order dealers are authorized and advertise the fact, but consumers are cautioned to be sure before ordering. If you need service on units purchased from unauthorized vendors, you'll have to pay full labor and parts rates.

DEC Drops LSI-11 Prices: Digital Equipment Corporation has lowered the prices on the 16-bit LSI-11 microcomputer products by almost 29%. Obviously, DEC is eager to compete with the new Intel 8086-, Zilog Z8000-, and Motorola 68000-based systems now coming on the market. In fact, the new prices compete well with 8-bit microcomputer systems. A complete LSI-11 system with 32 K bytes of programmable memory and I/O interfaces, assembled in a cabinet, lists for $2090. Also, the DEC RT-11 and FORTRAN package is now only $640—$40 more than the cost of a Microsoft CP/M FORTRAN package.

Packet Repeater Goes On The Air: The nation's first digital simplex packet-radio repeater (KA6M, Menlo Park, California) for amateur radio use has gone into operation. A similar system went into operation earlier in Vancouver, British Columbia, Canada. The station serves as a packet repeater and beacon. It receives a message or block of data and, after verification, retransmits that message on the same frequency. The message may have some address or control bytes altered. The repeater extends the range and coverage of fixed and mobile stations. It is the first step in what promises to be a nationwide network of interconnected computer systems that allow toll-free communications.

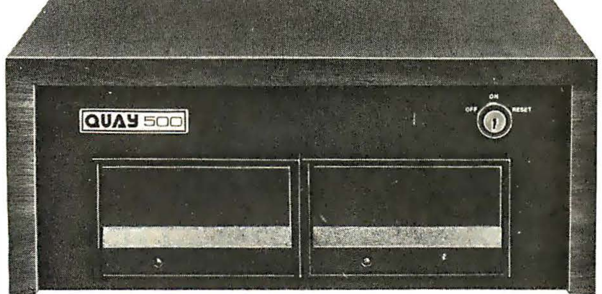
Ethernet Acceptance Spreading: Ethernet, the local networking system, appears to be emerging as the de facto network standard. Although created by Xerox, Intel and DEC have agreed to support it with integrated circuits and system interfaces. Now Zilog has acknowledged that it will implement Ethernet interfaces on its microcomputer systems. This is particularly noteworthy because Zilog is an Exxon subsidiary, and Exxon has announced its intention to develop a local-network system. Zilog's previously announced networking system Znet will still be supported by the company, in addition to the Ethernet interface.

Hewlett-Packard has made public that it will include Ethernet interfaces in some of its products. Digital Research intends to provide an Ethernet-to-CP/M software package.

MAIL: I receive a large number of letters each month as a result of this column. If you write to me and wish a response, please include a self-addressed stamped envelope.

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CP/M: A Family of 8- and 16-Bit Operating Systems

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Digital Research
POB 579
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This article is about microprocessors and CP/M: where they came from, what they are, and what they're going to be. Where they came from is history, what they are today is fact, and what they will become is, like any projection of technology, pure "science fiction" speculation. CP/M is an operating system developed for microcomputers. But as microprocessors changed, CP/M and its related programming tools evolved into a family of portable operating systems, languages, and applications packages.

The value of computer resources has changed dramatically with the introduction of microprocessors. Three major events have precipitated a revolution in computing: hand-threaded core memory has been replaced by mass-produced semiconductor memory; microprocessors have become plentiful; and IBM decided that the punched card is obsolete. Low-cost memory and processors have reduced the cost of computer systems to a few hundred dollars, but IBM's specification of the floppy disk standard has made the small computer system useful.

In the early days of the 8080 microprocessor, a small company called Shugart Associates was taking shape up the street from Intel. Shugart Associates, along with a number of other companies, viewed the floppy disk as more than a punched card replacement: at that time the primary low-cost storage medium was paper tape (used in applications ranging from program development to word processing). At a cost of $5, a floppy disk held as much data as two hundred feet of paper tape, and a disk drive retailed for only $500—an unbeatable combination. Memory, processor, and floppy-disk technology improved, and by the mid-1970s, a floppy-based computer could be purchased for about one quarter of a programmer's annual salary. Quite simply, it was no longer necessary to share computer resources.

Since that time, microprocessors have been applied to a variety of computing needs beyond replacement of low-end minicomputers. Due to applications such as machine-tool movement and sensing, data acquisition, and communications, current interest lies in real-time control. In a real-time operating system, process management can be separated from the I/O (input/output) system (which is not required in many applications). Real-time facilities allow the execution of interactive processes according to priority, and their addition or deletion in a simple fashion. This results in a custom operating system designed to solve a particular problem. In contrast to timesharing, real-time operating systems have minimal "interrupt windows" in which external interrupts are disabled. Real-time operating systems such as the Intel RMX and National Starplex packages provide this level of support.

The 16-bit version of CP/M is basically the same as the 8-bit version, with the addition of memory management and enhancements to the file system.

The emerging interest in *local networks* poses a new challenge to designers of operating systems. Recently, Intel, DEC (Digital Equipment Corporation), and Xerox formed an alliance to promote Ethernet, a *packet-switching* network intended to provide point-to-point data transfer in an office environment. (In a packet-switching network, data from several slow-speed sources, such as user terminals, is collected over local lines by a single network node, which then periodically transmits the data to its destination at a much higher speed, in groups called packets.) In terms of evolution and potential, Ethernet is today what floppy disks were a decade ago. This inexpensive office network performs such tasks as the transfer of a form letter from data storage at one location to a memory typewriter in another part of the

The Emergence of Software as a Problem-Solving Tool

Microprocessors are a natural consequence of our technology. I recently visited the British Science Museum, where two particularly interesting historical developments were on display. The first exhibit chronicled the development of the finely machined iron and brass steam engines, complete with magnificent gauges, gears, whistles, and valves, that founded the Industrial Revolution.

The second exhibit displayed progress in computing, beginning with Charles Babbage's inventions of the early 1800s. What did these exhibits have in common? They showed machines built with the same technology: Babbage's analytic engine might easily be mistaken for a small steam engine!

I followed the sequence of displays, from Babbage's difference and analytic engines to great brass calculators and early punch cards, past relay and vacuum tube processors to unit record equipment, then to transistor and random-logic computers and semiconductors and, finally, to a single Intel 8080 microprocessor.

Examined in this way, the technological momentum was obvious. Microprocessors are a direct result of our pattern of refinement through engineering. Just as a Boeing 727 is a refined version of the original Wright Brothers' invention, the microprocessor is a consequence of "fine tuning" by scientists and engineers who strive to understand, simplify, and add function to mankind's tools. There were several conspicuous spaces waiting to be filled following the 8080 display.

In public television's "Connections" series, James Burke claimed that we are a society filled with machines that do everything: sew materials for our clothes, carry us from coast to coast, and print millions of newspapers daily. But the most important machines in our society do absolutely nothing by themselves. These multifunctional devices provide a variety of services depending upon our needs, and herein lies the essential advantage: in the past, we identified a need and built a machine to satisfy that need; today, technology provides us with a single machine that we can instruct, through a program, to solve almost any problem. Where are the "Thomas Edisons" who used to build machines? Most are now inventing programs.

The evolution of our electronics industry typifies refinement through engineering. Beginning with electrical and electronic switches, we began manufacturing general-purpose function chips: put a value x on the input pins, define the function f by setting voltage levels on a second set of pins, and the result, f(x), magically appears on the output pins. Many examples of such integrated circuits exist, ranging from three-state logic gates to arithmetic/logic units.

With the introduction of microprocessors, the function f may be defined through instructions in a read-only memory allowing, in principle, the implementation of any function using a single device. A design that once required connecting resistors, capacitors, and logic gates has developed into a program that instructs a multipurpose machine to perform the same function. Controlling a stoplight and balancing a checkbook are now equivalent problems: both require the invention of a program.

Refinement through engineering: does this not also apply to software? To properly frame the answer, remember that the primary purpose of a computer is to be useful. Therefore, the application program is really the only important result of a software-engineering activity. Our primary goal in refining software tools is to provide the means for rapid and accurate generation of simple, understandable, and effective application programs. We do this through three levels of software support: system languages, operating systems, and application languages. These tools form an inverted pyramid underlying application software.

building. When modifications are completed, the letter is typed locally or sent to a laser (or other) printer that is a shared network resource.

Most timesharing systems handle a network through simple file transfers between the machines (*nodes*) in the net, but real refinements occur when the operating system itself is distributed among the nodes. File access is provided by one *server* node, while a computing function is performed by another. To the user, a *requester* node appears as a powerful computing facility, even though it may consist of only a local microprocessor, a console, and a limited amount of memory.

What refinements have been made to operating systems? Our models have been simplified; we understand primitive operations required for reliable process synchronization in real-time systems, and the human-oriented interface in interactive subsystems has been improved. We will, no doubt, continue to refine our models for timesharing and real-time operating systems, but the most exciting new operating system technology will develop around emerging network hardware.

Application Languages

Application languages form the top level of support for application programming. How does this level of language differ from other language levels? First and foremost, an application language contains the operations and data types suitable for expressing programs in a particular problem environment. FORTRAN (*FORmula TRANslation*), for example, was designed in the late 1950s for scientific applications; FORTRAN programs, therefore, consist primarily of algebraic expressions operating upon binary floating-point numbers expressed in scientific notation. However, FORTRAN contains only primitive file-access facilities and no decimal arithmetic, making it unsuitable for commercial data processing. COBOL (*COmmon Business Oriented Language*) has the commercial facilities, but it excludes scientific features such as a complete transcendental-function library.

In contrast to system languages that run on a given machine, these application languages would ideally contain no machine-dependent features. An application language is either poorly designed or ill-suited for a particular problem if the programmer is forced to use extra-lingual constructs to access lower-level functions of the operating system or machine. The language must be a standard, without the necessity for various locally defined language extensions. An extended standard language is of limited value since the extensions are unlikely to exist in other implementations.

The evolution of PL/I (*Programming Language/One*) provides a good example of refinement in application languages. PL/I is not a new invention: rather, it was defined by a committee of IBM users in 1960 as a combination of ALGOL (*ALGOrithmic Language*), FORTRAN, and COBOL, with a liberal sprinkling of new facilities. ALGOL's principal contribution was block structure and nested constructs, while FORTRAN contributed scientific processing and COBOL added commercial facilities. This combination produced a large, unwieldy language with twists and nuances that can trap the unwary programmer. Nevertheless, PL/I was quite comprehensive, and it served as the basis for uncounted numbers of application programs on large systems. One noted use of PL/I was in the implementation of the Multics operating system at MIT under Project MAC.

In 1976, an ANSI (American National Standards Institute) committee produced a standard language definition for PL/I. The standard is an implementation guide for compiler writers, and it precisely defines the form and function of each PL/I statement. Aware that PL/I was too large and complicated, the committee produced a smaller version for minicomputers, called Subset G. This new language excluded the redundancies and pitfalls of full PL/I but retained the

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useful application programming features. Recently approved by ANSI, Subset G has given new life to PL/I, with manufacturer support for the Data General Eclipse and MV/8000 computers, Prime computers, Wang machines, and DEC's popular VAX computer.

Strangely, the refinements found in application languages follow those of hardware and operating systems. Large, cumbersome languages have been rejected in favor of simple, Spartan programming systems that are consistent in their design. The resulting languages are easier to implement, simpler to comprehend, and allow straightforward program composition.

PL/M: The Base for CP/M

In 1972, MAA (Microcomputer Applications Associates), the predecessor of Digital Research, consulted with the small, aspiring microprocessor division of a semiconductor memory company called Intel Corporation. MAA defined and implemented a new systems-programming language, called PL/M (*Programming Language for Microcomputers*), to replace assembly-language programming for Intel's 8-bit microprocessor. PL/M is a refinement of the XPL compiler-writing language which is, in turn, a language with elements from Burroughs Corporation's ALGOL and the full set of PL/I.

The first substantial program written by MAA using PL/M was a paper-tape editor for the 8008 microprocessor, which later became the CP/M program editor, called ED. PL/M is a commercial success for Intel Corporation and, although licensing policies have limited its general accessibility, it has become the standard language of the Intel microprocessor world, with implementations for the 8080, 8085, and 8086 families.

MAA also proposed a companion operating system, called CP/M (*Control Program for Microcomputers*), which would form the basis for resident PL/M programming. The need for CP/M was obvious: 8080-based computers with 16 K bytes of main memory could be combined with

System Languages

A system language is a high-level machine-dependent programming language used to implement so-called "system software," including operating systems, text editors, debuggers, interpreters, and compilers. In the early days of computing, virtually all system software was implemented in assembly language. One revolutionary machine, the Burroughs B5500, used a variant of ALGOL-60 as its only system-programming tool and appeared in the early 1960s. The machine was a commercial success against the other major mainframes, proving that assemblers were no longer necessary. Many successful system languages followed Burroughs' ALGOL, including the C language, produced at Bell Laboratories in the late 1960s, which served as the basis for the UNIX operating system.

A system language, by definition, matches the architecture of a particular machine or class of machines; all facilities of the machine are accessible in the language, and the language contains no nontrivial extensions beyond the basic machine capabilities. The benefit is that a compiler for the system language is easy to implement and transport from machine to machine, as long as the architecture of each machine is similar. Further, a system language requires little run-time support since application facilities, such as extensive I/O (input/output) processing, are not generally embodied in the language.

Refinements in system languages are made by increasing their usability. Their acceptance as replacements for assembly languages is encouraging. Today, one can publicly admit that system software is implemented in a high-level language without implying that it must be rewritten in assembly language to be effective.

Operating Systems

Operating systems, too, have become more refined. But why do we have operating systems at all? In the 1960s we used expensive mainframes with power-hungry central processors and magnetic-core memory. Downtime for complicated card readers, printers, and backup data-storage devices was high, requiring constant maintenance. A card-oriented "batch" operating system provided two functions. First, it allocated processor time, memory, and peripherals to application programs in an attempt to utilize each expensive component to its fullest. Second, common I/O subroutines were a part of the operating system to avoid duplication in each application program. In the early 1960s, batch operating systems began to incorporate online *terminals that allowed the programmer to interact with the program—this is where things became interesting. With an online terminal, a program could write a prompt message, read the data entered by the operator, and write a response almost instantly.*

The crude terminal systems evolved into today's timesharing computers, where program interaction is the primary function, with batch processing in the background. General Electric and Digital Equipment Corporation led the way with BASIC-based 235 and multilingual PDP-10 computers. Countless timesharing operating systems followed, including IBM's interactive APL and CP/CMS, along with UNIX from Bell Laboratories. These timesharing systems were the forerunners of personal computing: all assumed that the hardware was too expensive to dedicate, so each terminal becames an emulation of a single computer.

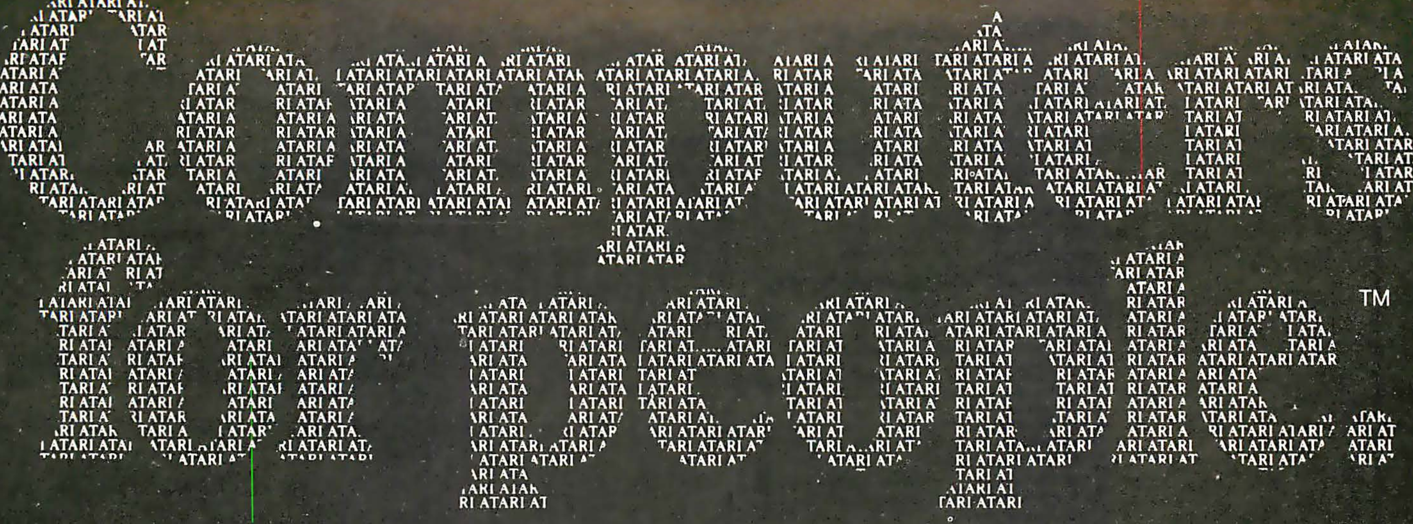
Shugart's new (at that time) floppy-disk drives to serve as development systems. For the first time, it was *feasible* to dedicate a reasonably powerful computer to the support of a single engineer. But the use of PL/M on larger timesharing computers was considered sufficient, and the CP/M idea was rejected.

The CP/M Family

CP/M was, however, completed by MAA in 1974. It included a single-user file system designed to eliminate data loss in all but the most unlikely situations, and used recoverable directory information to determine storage allocation rather than a traditional linked-list organization. The simplicity and reliability of the file system was an important key to the success of CP/M: file access to relatively slow floppy disks was immediate, and disks could be changed without losing files or mixing data records. And because CP/M is a Spartan system, today's increased storage-media transfer rates simply improve overall response. The refinements found in CP/M are based on its simplicity, reliability, and a proper match with limited-resource computers.

By the mid-1970s, CP/M added a new philosophy to operating system design. CP/M had been implemented on several computer systems, each having a different hardware interface. To accommodate these varying hardware environments, CP/M was decomposed into two parts: the invariant disk operating system written in PL/M, and a small variant portion written in assembly language. This separation allowed computer suppliers and end users to adapt their own physical I/O drivers to the standard CP/M product.

Hard-disk technology added yet another factor. CP/M customers required support for disk drives ranging from single 5-inch floppy disks to high-capacity Winchester disk drives. In response, CP/M was totally redesigned in 1979 to become *table-driven*. All disk-dependent parameters were moved from the invariant disk operating system to tables in the





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"Underground Guide to Buying a Computer"
Published 1980, SCELBI Publications

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variant portion, to be filled in by the system implementer.

CP/M is now a multifunction program whose exact operation is defined externally through tables and I/O subroutines. The widespread use of CP/M is directly attributed to this generality: CP/M becomes a special-purpose operating system when it is field-programmed to match an operating environment. Through the efforts of system implementers who provide this field-programming, CP/M is used worldwide in close to 200,000 installations with over 3000 different hardware configurations.

CP/M, PL/I, and PL/M have all played a role in the development of CP/M-86.

MP/M

As single-user CP/M became widely accepted, Digital Research began to develop a new operating system for real-time processing. The design called for a real-time nucleus to support cooperating sequential processes, including a CP/M-compatible file manager with terminal-handling capabilities. This operating system, called MP/M (*Multiprogramming Monitor for Microcomputers*), is a further refinement of the process model found in Intel's RMX and National's Starplex. As a side effect, the combination of MP/M's real-time nucleus with the terminal handler and the CP/M file system produces a traditional timesharing system with multiprogramming and multiterminal features.

Timesharing allows programs to execute in increments of processor time in a "lock-step" fashion. In a timesharing context, a printer program, often called a *spooler*, might have the task of printing a series of disk files which result from program output. The spooler starts with a disk-file name and, by using increments of processor time allocated by the real-time nucleus, writes each line from the file to the printer. Upon completion, the spooler obtains another disk-file name and repeats

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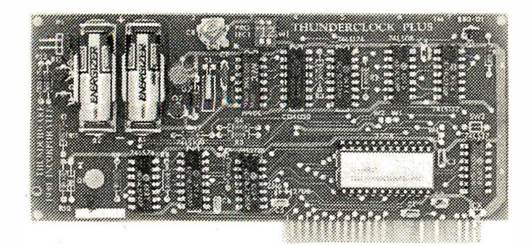
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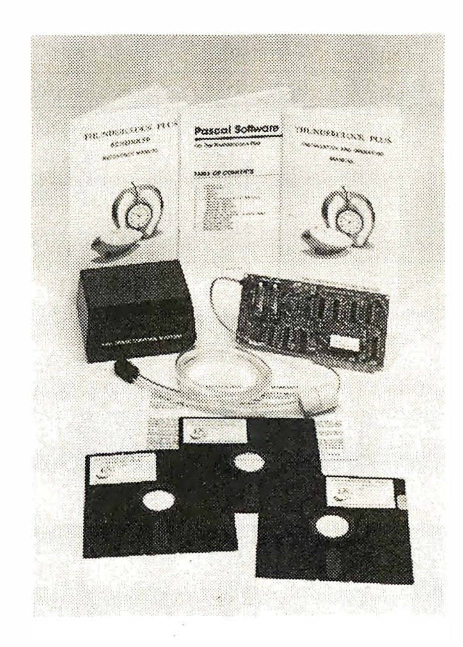
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the process. You can, for example, send the name of a disk file to the spooler and, while the file is being printed, edit another file in preparation for compilation. The spooler and editor share processor time to complete their respective tasks. In general, many such processes share processor time and system resources.

MP/M process communication is performed through *queues* (or waiting lines) managed by the nucleus. The spooler, for example, reads file names from an input queue posted by another process (which reads spooler command lines from the console). When the spooler is busy printing a file, additional file names may enter the input queue in a first-in first-out order.

Process synchronization through queuing mechanisms is commonplace, but MP/M treats queues in a unique manner, simplifying their use and decreasing queue management overhead. Queues are treated as files: they are named symbolically so that a queue can be added dynamically. Like files, queues have queue control blocks that are created, opened, deleted, written, and read. In fact, the set of queue operations closely matches the file functions of CP/M so that MP/M provides a familiar programming environment.

The implementation of queues is transparent to an operator or system programmer, but it is important to MP/M's effective operation on limited-resource computers. Queues are implemented through three different data structures, depending upon the message length. So-called "counting semaphores" count the occurrence of an event with message length zero, and are implemented as 16-bit tallies. Single-byte messages are processed using a circular buffer. Similarly, queues containing addresses are processed using circular buffers. In all other cases, MP/M uses a general linked list, which requires additional space and processing time. It is this sensitivity to the capabilities of limited-resource computers that makes MP/M effective: while real-time operating systems often incur 25 to 40% overhead, MP/M has been streamlined to increase available compute time by 7% over single-user CP/M.

Like CP/M, MP/M is separated into variant and invariant portions. The file-system interface is identical to that of CP/M, with the addition of user-defined functions to handle non-CP/M operations (such as control of the real-time clock). Field-reconfiguration of MP/M allows a variety of device protocols including CP/M-style busy-wait loops, polled devices, and interrupt-driven peripherals. In fact, the variety of interface possibilities makes the MP/M implementer a true system-software designer, since a fine-tuned MP/M system may operate considerably faster than its initial implementation.

What are the refinements found in MP/M? First, it is a state-of-the-art operating system based on current process-synchronization technology and microprocessor real-time system design philosophies. Process communication is conceptually simple and requires minimal overhead. Finally, it is the only operating system of its type that can be field-tailored to match almost any computer configuration.

CP/NET

CP/NET, introduced in late 1980, leads a series of network-oriented operating systems that distribute operating system functions throughout a network of nonhomogeneous processors. CP/NET connects CP/M requesters to MP/M servers through the use of an arbitrary network protocol. Similar to CP/M and MP/M, CP/NET consists of the invariant portion, along with a set of field-reconfigurable subroutines that define the interface to a particular network. For purposes of CP/NET, this interface need only provide point-to-point data-packet transmission. Since the actual data transmission media are unimportant to CP/NET, any one of the number of standard protocols can be used, from low-speed RS-232C through high-speed Ethernet. Physical connections are also arbitrary, allowing active hub-star, ring, and common-bus architectures.

The invariant portions of CP/NET operate under a standard CP/M system to direct various system calls over the network to an MP/M server. The MP/M server, in turn, responds to network requests by simulating the actions of CP/M. This simulation is transparent to an application program: any program operating under standard CP/M operates properly in the network environment.

Suppose, for example, you wish to store common business letters in a central data base under MP/M and access these letters from a CP/M-based word processor. You begin by assigning one local disk drive to the MP/M master, using the CP/NET interface. You then direct your word processing system to read the particular letter on the assigned drive, causing the data to be obtained from the server rather than from the local disk. After local update using your word processor, you can print the result on your local printer or optionally assign your listing device to the network for printing at the MP/M server.

CP/NET is accompanied by three related network operating systems: CP/NOS, MP/NET, and MP/NOS. CP/NOS is, in effect, a diskless CP/M, which can be stored in read-only memory, and that operates with a console, memory, and network interface. MP/NET, on the other hand, is a complete MP/M system with an embedded network interface that, like CP/NET, allows local devices to be reassigned to the network. MP/NET configurations allow MP/M systems as both requesters and servers with CP/M requesters. Finally, MP/NOS contains the real-time portion of MP/M without local disk facilities. Like CP/NOS, MP/NOS performs all disk functions through the network.

The interface protocol is publicly defined so that non-MP/M or non-CP/M systems can participate in network interactions. A server interface for the VAX 11/780, for example, is under preparation so that it can perform I/O functions for a large number of MP/M and CP/M requesters.

The principal advantage of CP/NET is that all CP/M-compatible software becomes immediately available for operation in the network en-

vironment, solving the problem that builders of network hardware face: the total absence of application software. Although the promise is there, networking is in its infancy, and CP/NET is truly a software package awaiting the evolution of suitable hardware.

PL/I: The Application Language

In 1978, Digital Research investigated the final level of software support: application languages. One such language was to be supported throughout the operating system product line, and the choice would have to be a multipurpose language. Further, the language would have to be an international standard to promote the generation of software by independent vendors. Standard Pascal seemed a logical choice but was rejected for several reasons. First, Pascal is an ALGOL derivative with scientific orientation. Commercial facilities in the standard language are absent: decimal arithmetic, file processing, string operations, and error-exception handling were essential. Further, separate compilation and initialization of tables were not in the language. There was a temptation to extend Pascal in order to include these features, but these extensions would have defeated the benefits of standardization.

PL/I Subset G was the obvious choice. It satisfied scientific and commercial needs and, because of subset restrictions, was consistent and easy to use. The project was a bit daring, however, because Subset G was unknown in the computer community. PL/I was viewed as a large IBM-oriented language with huge, inefficient compilers that required tremendous runtime support.

The Digital Research implementation of Subset G was started in mid-1978 and completed two years later. The compiler is a three-pass system written in PL/M. The first two passes are machine independent and produce symbol tables and intermediate language suitable for any target machine. The third pass is largely machine dependent and is dedicated to code optimization and final machine-code production. The compiler is accompanied by a linkage editor (compatible with the Microsoft format), a program librarian, a set of runtime subroutines, and a relocating macro assembler.

Thus, PL/I completes the final level of the inverted pyramid of support tools. The message should be clear to the application programmer: it is not the system language or the operating system which is important in the production of a final application. Rather, it is the availability of a standard, widely accepted application language that can provide program longevity. Once expressed in PL/I Subset G, the program can be transported through the CP/M family of operating systems to a variety of minicomputer systems. Digital Research has a long-term commitment to PL/I support for popular operating systems and processors.

New Processor Architectures

We've spent little time discussing processor refinements. What is happening to our software tools as we augment our 8-bit machines with the more powerful 16-bit processors? Will 16-bit processors replace 8-bit machines, or are they simply a temporary phenomenon in the transition to 32-bit machines?

There are several considerations when answering these questions. First, 8-bit machines are economical to produce, their software systems are mature, and they satisfy the needs of a substantial computer base. Therefore, we can safely assume that 8-bit machines are here to stay. Newer 16-bit machines are marginally faster, but they have substantially more address space. To use this additional address space, the computer must contain more memory, which increases the computer system cost.

As system costs increase, the margin between low-end minicomputers and high-end microcomputers diminishes, placing microcomputer hardware and software manufacturers such as ourselves in direct competition with major minicomputer manufacturers. The 16-bit machines, by their nature, introduce memory segmentation problems that are not

present in 32-bit processors.

Finally, we should note that 16-bit minicomputers are already outmoded, and all serious manufacturers are pushing 32-bit machines. This leads to the following conclusion: if we are tracking the minicomputer world, we can assume that the future will be with the 32-bit processors.

Currently, however, 32-bit machines are not available in quantity. Even when they are available, there will be delays while manufacturers tool up for production. At the moment, the 16-bit processors offer an intermediate solution. Digital Research has provided initial support for Intel's 16-bit machines—iAPX-186 and iAPX-286—which are versions of its 8086 product line. Intel provided PL/M-86, rehosted from the 8080 line, which was used by Digital Research to generate CP/M-86 and MP/M-86. In both cases, the fundamental design remains basically the same as that of the 8-bit version, with the addition of memory management and enhancements to the file system that match new computing resources. A familiar program environment is retained so that program conversion is simplified.

CP/NET and related network software will be available sometime this year. Intel's 8087 (an arithmetic coprocessor for the 8086) is of particular interest since it directly supports binary and decimal operations, which substantially increase PL/M-86 execution speed.

In addition to the 8086, the CP/M family will be adapted to the 16-bit machines that prove popular, with special interest in the 32-bit architectures as they become available. During this development and rehosting, however, the 8-bit processors will continue to be supported with new tools and facilities, since this constitutes, without doubt, our best customer base for some time to come.

Software Vendors

We've concerned ourselves with three levels of software tools that support the most important level: the application programs. A major reason for CP/M's popularity is the general availability of good application software. At last count, there were about 500 commercially available CP/M-compatible software products.

Through the combined efforts of CP/M distributors, independent vendors, and CP/M users, we are participating in a software commodity market with quality and variety that is unequaled by any minicomputer or mainframe manufacturer. The large CP/M customer base allows a vendor to produce and support a software package at low end-user cost. This increases the customer base, drawing more vendors with lower-cost good-quality products. This cyclic effect is, today, solving the "software crunch."

The tools are available, and it is the responsibility of independent software vendors to continue developing their own specialized markets. In this way, computer software technology will reach virtually all application areas where low-cost, reliable computing is required. Refinements? My friend, they're up to you. ■

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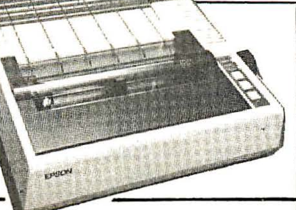
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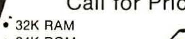
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LIST—A Source-Listing Program for the C Language

Jeff Taylor, The Toolsmith
POB 22511, San Francisco CA 94122

Most UNIX-system utilities read from a standard input device and write to a standard output device. The Whitesmiths C compiler shows its heritage by doing the same. Until it informs you, for example, that there is a semicolon missing on some line, you don't notice that the source listing isn't being printed. LIST is a program to print source listings. (See listing 1.) Each line is labeled like the compiler's error listing. The version presented here is a system note, and you will probably want to add more features.

About the Author
Jeff Taylor is the owner of The Toolsmith, a software house. He received his bachelor's degree and did graduate work in electrical engineering, specializing in computer science, at the University of California, Davis.

LIST reads the files named on command line and writes the listing to the standard output. If the files are not named, input is taken from the standard input. The standard input and output default to the user's terminal but can be redirected to or from other devices or files, such as the line printer. Each file's listing starts a new page. At the top of each page is the file's name, the page number, and the date. Obtaining the date from the operating system depends upon your equipment; the code shown is for RT-11. The function DATE returns the number of bytes in the date and puts the date's character string in its single argument.

The C language allows an #include statement. The preprocessor pass of the compiler replaces the #include statement with the contents of the file it names. As an option, LIST can insert the contents of the file after the #include statement. The −n flag on the command line turns on #include processing for nonheader files. The −h option includes header files. Header files are those with the extension .H (such as STD.H, which is the standard header file supplied by Whitesmiths). The depth to which #include can be nested depends on your stack size. Listing 1 was printed by the command:

```
list −n > lp: list.c
```

where lp: is the line printer. The #include processing was performed excluding header files. The angle brackets (< and >) indicate redirection of the standard input and output, respectively.

The subroutine PAGINATE uses a technique that is described in *Principles of Program Design* by M A Jackson. If each print line could be read from a scratch

Text continued on page 246

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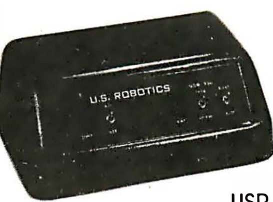
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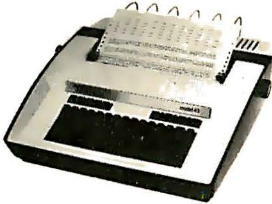
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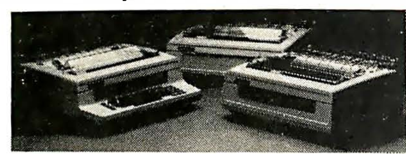
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Listing 1: *The program LIST. Normal operation produces a listing with pagination, top and bottom margins on each page, and a header on each page.*

```
list.c                                   Page: 1        24 October 1980

list.c            1: #include <std.h>
list.c            2: #include <local.h>
list.c            3: /*  lister - list 'c' source files
list.c            4: */
list.c            5:
list.c            6: FIO stdin;       /* standard input buffer */
list.c            7:
list.c            8: BOOL n_flag = NO;
list.c            9: BOOL h_flag = NO;
list.c           10:
list.c           11: #include "diagn.c"
diagn.c           1:
diagn.c           2: /* diagnostic - spit out error message */
diagn.c           3: diagnostic(fatal,args)
diagn.c           4:   BOOL fatal;
diagn.c           5:   TEXT *args;
diagn.c           6:   {
diagn.c           7:   FAST TEXT **a;
diagn.c           8:
diagn.c           9:   for(a = &args; *a != NULL; ++a)
diagn.c          10:     write(STDERR,*a,lenstr(*a));
diagn.c          11:   write(STDERR,"\n",1);
diagn.c          12:   if(fatal)
diagn.c          13:     exit(NO);
diagn.c          14:   }
list.c           12:
list.c           13: #include "pagin8.c"
pagin8.c          1:
pagin8.c          2: #include "date.c"
date.c            1:
date.c            2: /* date - return current date, if any in "buf" */
date.c            3: BYTES date(buf)
date.c            4:   FAST TEXT *buf;
date.c            5:   {
date.c            6:   BYTES itob();
date.c            7:   COUNT emt();
date.c            8:   FAST TEXT *b = buf;
date.c            9:   TEXT *cpystr();
date.c           10:   union _date {
date.c           11:     COUNT all;
date.c           12:     struct {
date.c           13:       unsigned year:5;
date.c           14:       unsigned day:5;
date.c           15:       unsigned month:5;
```

```
list.c                                   Page: 2        24 October 1980

date.c           16:       };
date.c           17:     } tmp;
date.c           18:   static TEXT *months[] = {"January","February","March","April","May","June",
date.c           19:     "July","August","September","October","November","December"};
date.c           20:
date.c           21:   tmp.all = emt(0374,012<<8);    /* system call */
```

Listing 1 continued on page 238

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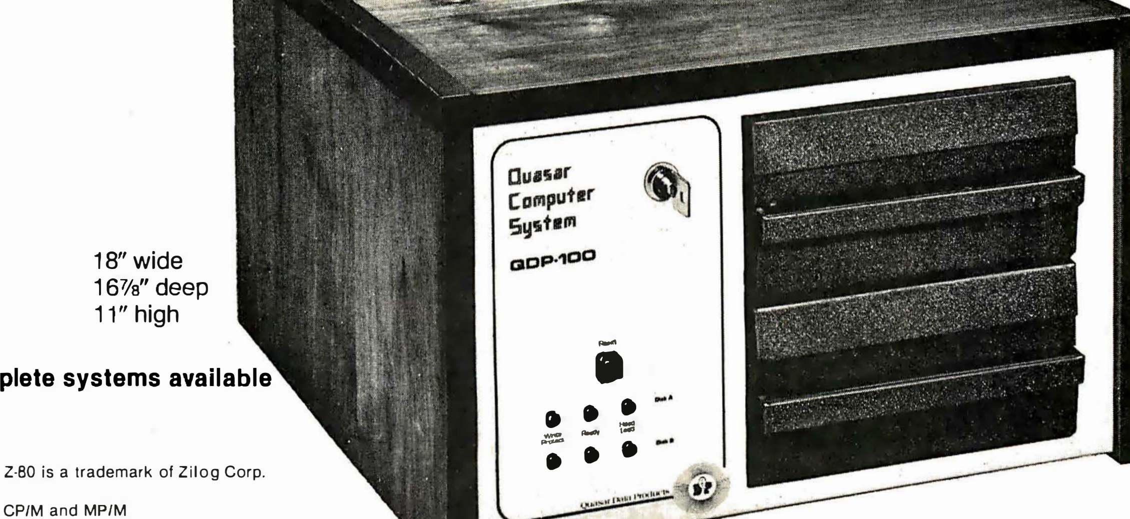
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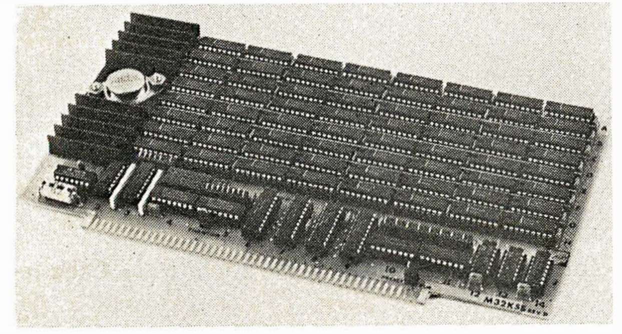
Circle 305 on inquiry card.

Listing 1 continued:

```
date.c          22:    if(tmp.all == 0)        /* no date */
date.c          23:      return(0);
date.c          24:    buf += itob(buf,tmp.day,0);    /* day of month */
date.c          25:    buf = cpystr(buf," ",months[tmp.month-1]," ",NULL);    /* month of year */
date.c          26:    buf += itob(buf,tmp.year+1972,0);      /* year A.D. */
date.c          27:    return(buf-b);
date.c          28:    }
pagin8.c         3:
pagin8.c         4: /* skip - output "n" blank lines */
pagin8.c         5: COUNT skip(n)
pagin8.c         6:    FAST COUNT n;
pagin8.c         7:    {
pagin8.c         8:    FAST COUNT t = n;
pagin8.c         9:
pagin8.c        10:    while(t-- > 0)
pagin8.c        11:      putch('\n');
pagin8.c        12:    return(n);
pagin8.c        13:    }
pagin8.c        14:
pagin8.c        15: #define MARGIN1 3          /* top of page to title line */
pagin8.c        16: #define MARGIN2 2          /* title line to body */
pagin8.c        17: #define MARGIN3 2          /* body to bottom of page */
pagin8.c        18:
pagin8.c        19: TEXT *title = NULL;
pagin8.c        20: int page_size = HARD_PAGE;       /* lines per page */
pagin8.c        21:
```

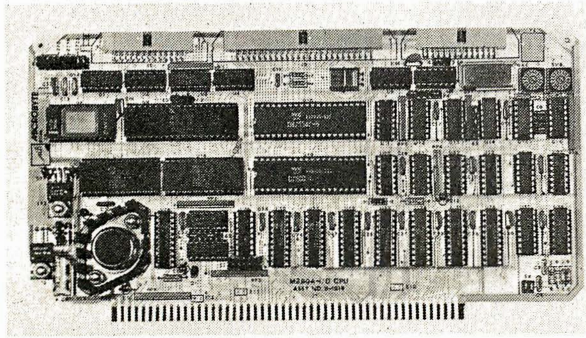
Listing 1 continued on page 240

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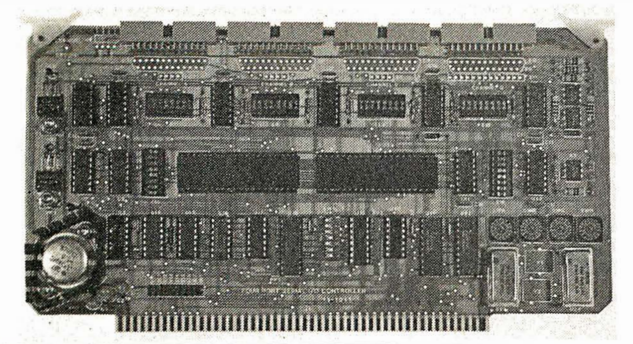
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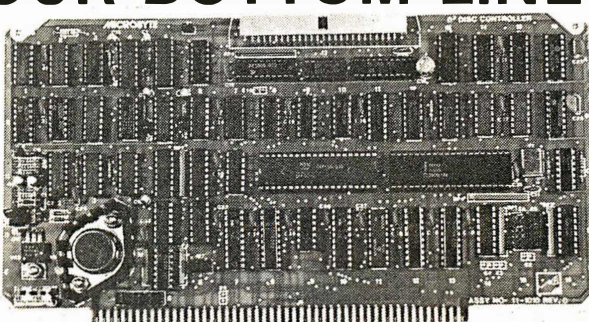
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- 4K hardware or software selectable
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- No DMA restriction
- Low power consumption 800mA
- Fully warranted for 120 days from date of shipment



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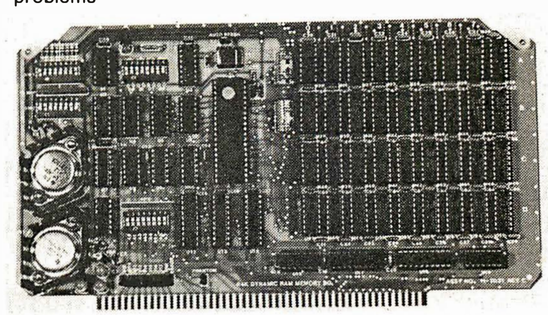
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Listing 1 continued:

```
pagin8.c        /* paginate - separate stream of buffers into pages */
pagin8.c        paginate(buf)
pagin8.c          TEXT *buf;
pagin8.c          {
pagin8.c          BYTES date(),itob(),lenstr(),putlin();
pagin8.c          static int line;       /* line number within page */
pagin8.c          static int page = 0;
pagin8.c          TEXT tmp[20];
pagin8.c
pagin8.c          if(page != 0) /*  M. A. Jackson's program inversion technique used */
pagin8.c            goto resume;
pagin8.c          /*  read  */
```

```
list.c                          Page: 3          24 October 1980

pagin8.c          while(buf != NULL) {  /* while(!end_of_file) */
pagin8.c            ++page;
pagin8.c            line = skip(MARGIN1);
pagin8.c            if(title != NULL) { /* output title, page # & date */
pagin8.c              putlin(title,lenstr(title));
pagin8.c              putlin("\t\t\t\t\t Page: ",12);
pagin8.c              putlin(tmp,itob(tmp,page,0));
pagin8.c              putlin("\t",1);
pagin8.c              putlin(tmp,date(tmp));
pagin8.c              line += skip(MARGIN2);
pagin8.c              }
pagin8.c            while(buf != NULL && line < page_size-MARGIN3) {
pagin8.c              putlin(buf,lenstr(buf));
pagin8.c              ++line;
pagin8.c              /*  read  */
pagin8.c              return;
pagin8.c        resume: ;
pagin8.c              }
pagin8.c            skip(page_size-line);
pagin8.c            line = 0;
pagin8.c            }
pagin8.c          page = 0;
pagin8.c          }
list.c
list.c          #include "incl.c"
incl.c
incl.c          /* include - include file in s */
incl.c          COUNT include(file,ftn)
incl.c            FAST TEXT *file;
incl.c            COUNT (*ftn)();
incl.c            {
incl.c            FAST COUNT return_code;
incl.c            TEXT *buybuf();
incl.c            FAST FIO *fd;
incl.c            FIO *fclose(),*fopen();
incl.c
incl.c            return_code = NO;
incl.c            fd = (FIO *) buybuf(&stdin,sizeof(FIO));
incl.c            if(fopen(&stdin,file,READ) == NULL)
incl.c              diagnostic(NO,"can't open ",file,NULL);
incl.c            else {
```

```
incl.c          17:     return_code = (*ftn)(file);
incl.c          18:     fclose(&stdin);
incl.c          19:     }
```

```
list.c                                   Page: 4        24 October 1980

incl.c          20:   cpybuf(&stdin,fd,sizeof(struct fio));
incl.c          21:   free(fd);
incl.c          22:   return(return_code);
incl.c          23:   }
list.c          16:
list.c          17: #include "filenm.c"
filenm.c         1:
filenm.c         2: TEXT *prefix = "";       /* include prefix */
filenm.c         3:
filenm.c         4: /* get_name - extract file name from line */
filenm.c         5: BYTES get_name(line,file)
filenm.c         6:   TEXT *file,*line;
filenm.c         7:   {
filenm.c         8:   TEXT *delim;
filenm.c         9:   BYTES cpybuf(),instr(),lenstr(),n;
filenm.c        10:
filenm.c        11:   while(*line == ' ' || *line == '\t')
filenm.c        12:     ++line;
filenm.c        13:   if(*line == '\n')
filenm.c        14:     n = lenstr(file);
filenm.c        15:   else {
filenm.c        16:     n = 0;
filenm.c        17:     if(*line == '"') {
filenm.c        18:       delim = "\"\n";
filenm.c        19:       ++line;
filenm.c        20:       }
filenm.c        21:     else if(*line == '<') {
filenm.c        22:       delim = ">\n";
filenm.c        23:       ++line;
filenm.c        24:       n = cpybuf(file,prefix,lenstr(prefix));
filenm.c        25:       }
filenm.c        26:     else
filenm.c        27:       delim = " \t\n";
filenm.c        28:     n += cpybuf(file+n,line,instr(line,delim));
filenm.c        29:     *(file+n) = EOS;
filenm.c        30:     }
filenm.c        31:   return(n);
filenm.c        32:   }
list.c          18:
list.c          19: #include "detab.c"
detab.c          1:
detab.c          2: /* detab - replace tabs with blanks */
detab.c          3: BYTES detab(s,d)
detab.c          4:   FAST TEXT *s,*d;
```

```
list.c                                   Page: 5        24 October 1980

detab.c          5:   {
detab.c          6:   FAST BYTES i;
```

Listing 1 continued on page 244

Circle 265 on inquiry card.

Listing 1 continued:

```
detab.c          7:
detab.c          8:    for(i = 0; *d = *s; ++s)
detab.c          9:      if(*s == '\t')
detab.c         10:        do
detab.c         11:          *d++ = ' ';
detab.c         12:        while(++i%8);
detab.c         13:      else {
detab.c         14:        ++i;
detab.c         15:        ++d;
detab.c         16:        }
detab.c         17:    return(++i);
detab.c         18:    }
list.c          20:
list.c          21: /* check_include - do possible include processing */
list.c          22: check_include(line)
list.c          23:    FAST TEXT *line;
list.c          24:    {
list.c          25:    FAST BYTES n;
list.c          26:    TEXT file[MAXFILE+1];
list.c          27:    int list();
list.c          28:
list.c          29:    for( ; iswhite(*line); ++line)          /* skip leading blanks */
list.c          30:      ;
list.c          31:    if(cmpbuf(line,"#include ",9)) {
list.c          32:      n = get_name(line+9,file);
list.c          33:      if(cmpbuf(&file[n-2],".h",2)) {      /* header file */
list.c          34:        if(h_flag)
list.c          35:          include(file,&list);
list.c          36:        }
list.c          37:      else {       /* non-header file */
list.c          38:        if(n_flag)
list.c          39:          include(file,&list);
list.c          40:        }
list.c          41:      }
list.c          42:    }
list.c          43:
list.c          44: /* list - label and print lines of "file" */
list.c          45: list(file)
list.c          46:    TEXT *file;
list.c          47:    {
list.c          48:    BYTES getlin(),itob();
list.c          49:    TEXT *alloc(),*buf,*line,temp[4];
---------------------------------------------------------------------------------

list.c                                  Page: 6       24 October 1980

list.c          50:    FAST BYTES l,t;
list.c          51:    FAST COUNT line_number = 0;
list.c          52:    #define BORDER MAXFILE+7          /* assumes < 1000 lines */
list.c          53:
list.c          54:    buf = alloc(HARD_WIDTH+1,0);
list.c          55:    line = alloc(MAXLINE+1,0);
list.c          56:    fill(buf,BORDER,' ');
list.c          57:    buf[BORDER-2] = ':';
list.c          58:    cpybuf(buf,file,lenstr(file));
list.c          59:    while(l = getlin(line,MAXLINE)) {
list.c          60:      line[min(l,HARD_WIDTH-BORDER)] = EOS;
```

Listing 1 continued on page 246

if He'd used select™ it wouldn't have taken seven days

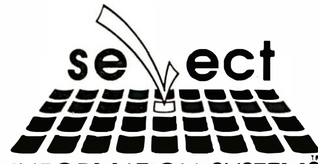
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Circle 327 on inquiry card.

Listing 1 continued:

```
list.c          61:       t = itob(temp,++line_number,0);
list.c          62:       cpybuf(buf+BORDER-2-t,temp,t);
list.c          63:       detab(line,buf+BORDER);
list.c          64:       paginate(buf);
list.c          65:       if(n_flag || h_flag)
list.c          66:         check_include(line);
list.c          67:       }
list.c          68:     }
list.c          69:
list.c          70: BOOL main(ac,av)            /* handles program arguments */
list.c          71:     BYTES ac;
list.c          72:     TEXT **av;
list.c          73:     {
list.c          74:     FAST TEXT *s;
list.c          75:     TEXT buf[MAXLINE+1],*getflags();
list.c          76:
list.c          77:     if(s = getflags(&ac,&av,"h,i*,n,p#",&h_flag,&prefix,&n_flag,&page_size))
list.c          78:       diagnostic(NO,"bad flag:",s,NULL);
list.c          79:     if(ac <= 0) {
list.c          80:       list("");
list.c          81:       paginate(NULL);
list.c          82:       }
list.c          83:     else {
list.c          84:       do {
list.c          85:         title = *av;
list.c          86:         include(title,&list);
list.c          87:         paginate(NULL);
list.c          88:         } while(++av,--ac);
list.c          89:       }
list.c          90:     }
```

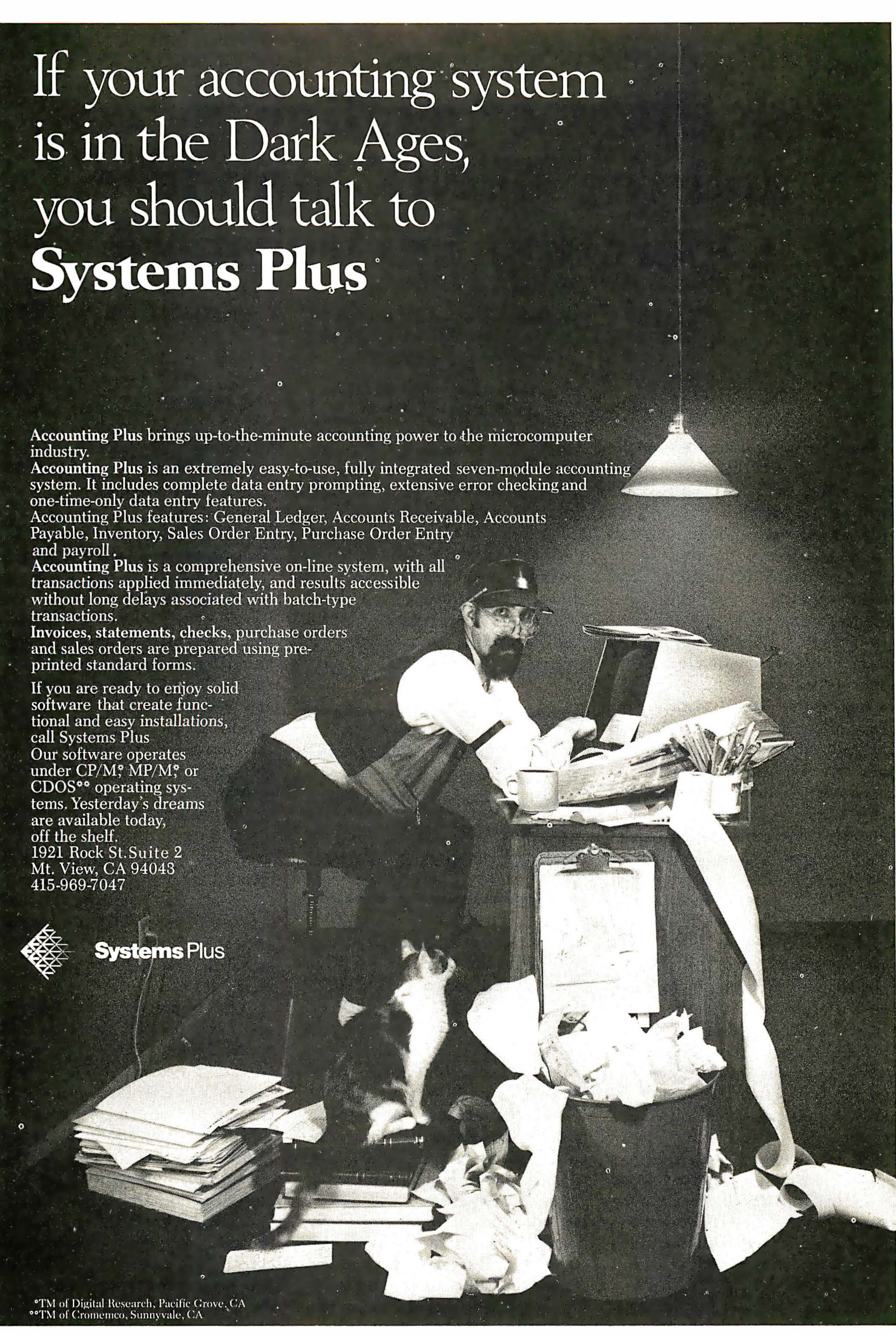
Text continued from page 234:

file, this is what the subroutine would look like in pseudocode:

```
read line;
while(not end of file) {
   do page header;
   while(not (end of file || bottom of page)) {
      print line;
      read line;
      }
   do page footer;
   }
```

For efficiency and simplicity, a *pointer* to each line is *passed* to PAGINATE instead of read from a file. A NULL pointer indicates end-of-file. The usual method is to turn the code inside out around the read statements. Jackson advocates keeping the structure the same and replacing each read statement by an assignment to a state variable, a return statement, and a label. The state variable serves as a "bookmarker," so that execution can resume where it left off. A switch statement at the subroutine entrance will jump to the proper label on the next call. This technique may not be well received by the more fanatical GOTOless programming advocates, but this was the first paginate subroutine I have written that worked perfectly on the first try. In PAGINATE, the page counter is used as the state variable. If PAGE equals 0, then execution continues at the first read statement; otherwise, it jumps to the read in the innermost loop.

LIST did not spring full-blown from an exhaustive design process but evolved over a period of time. As with most computer efforts, I had only a general idea of the requirements—features were added, removed, and generalized. The header-file exclusion option originally only affected the standard header file STD.H. Functions were moved around within the code to tighten up the structure or to generalize a subroutine. Concatenating the file name, line number, and source line was originally done in PAGINATE. Moving it out allowed PAGINATE to be used in other programs. Several extensions are being contemplated, but the cost (in time) to implement them exceeds the cost of not having them. Being able to exclude an include file by name (−x filename) would be useful on large programs with a lot of previously developed code. When the preprocessor conditional compilation statements #if and #ifdef are used, it's practical to have LIST handle them correctly. Each of these extensions would, however, require more time to implement than the existing program. ■



Circle 350 on inquiry card.

The UNIX Operating System and the XENIX Standard Operating Environment

Robert B Greenberg
XENIX Product Manager
Microsoft
10800 NE Eighth, Suite 819
Bellevue WA 98004

Never has there been a greater demand for software that is easy to use and maintain, and independent of the hardware on which it runs. As the price of software rapidly outpaces that of computers, the need to increase software productivity and reduce duplication of effort has become paramount.

Microsoft's XENIX operating system offers one solution to the software crisis developing in the microcomputer world. Unlike the operating systems offered for 8-bit machines, the XENIX system is a powerful multiuser timesharing system with hundreds of utilities and is the basis for a highly productive software development environment and a general-purpose applications system.

The XENIX operating environment combines two key elements: the design of the widely acclaimed UNIX operating system and the inclusion of the major high-level languages that are standard within the 8-bit microcomputer world (see figure 1). Microsoft's transport of the XENIX system to major 16-bit microprocessors has made it the first hardware-independent operating system.

The heart of the XENIX system is the UNIX operating system developed at Bell Laboratories and licensed by Western Electric. The UNIX system's elegant design combines power, flexibility, and simplicity, and its vast array of software utilities greatly increases productivity. Thus, the UNIX system is an ideal candidate to serve as a solution to the software crisis.

Microsoft plans to make the XENIX operating system (which is an enhanced version of the UNIX system) into a commercial standard. And, in addition to supporting and enhancing the operating system proper, Microsoft will adapt high-level languages, such as its BASIC interpreter and compiler, FORTRAN, Pascal, and COBOL, and other software tools, such as data-base management and communications software, to run under the XENIX operating system.

The XENIX system is one approach to solving the software crisis developing in the microcomputer world.

To understand the elegance of the basic UNIX design and the further enhancements in the XENIX system, we must take a closer look at the software. In this article, I will describe the main features in the UNIX operating system, discuss some of its strengths and weaknesses, and conclude with a discussion of the evolution of the XENIX operating environment from the UNIX operating system, and how it can help solve critical software issues. First, a historical overview.

Origins of the UNIX OS

The UNIX operating system was originally developed at Bell Laboratories by Ken Thompson, an employee engaged in various programming research projects. With access to an abandoned DEC PDP-7 computer that had no software, Thompson decided in 1969 to write a set of programs that would aid him in software research. Over a period of several years, and with the help of fellow researcher Dennis Ritchie, this set of programs evolved into a full operating system. By 1972, it was recoded for the DEC PDP-11 computer in a newly designed high-level language, called C. The system gained recognition within the Labs and their parent company, Western Electric.

Word of the quality of Thompson and Ritchie's UNIX operating system spread rapidly. Universities, in particular, expressed interest in obtaining UNIX, and in 1973, Western Electric agreed to distribute the system to nonprofit organizations and promptly licensed several dozen educational institutions, including Columbia University, the University of Alberta (Canada), The Children's Museum (Boston), Princeton University, and Harvard University. By 1975, UNIX had become sufficiently popular in the academic world to justify the

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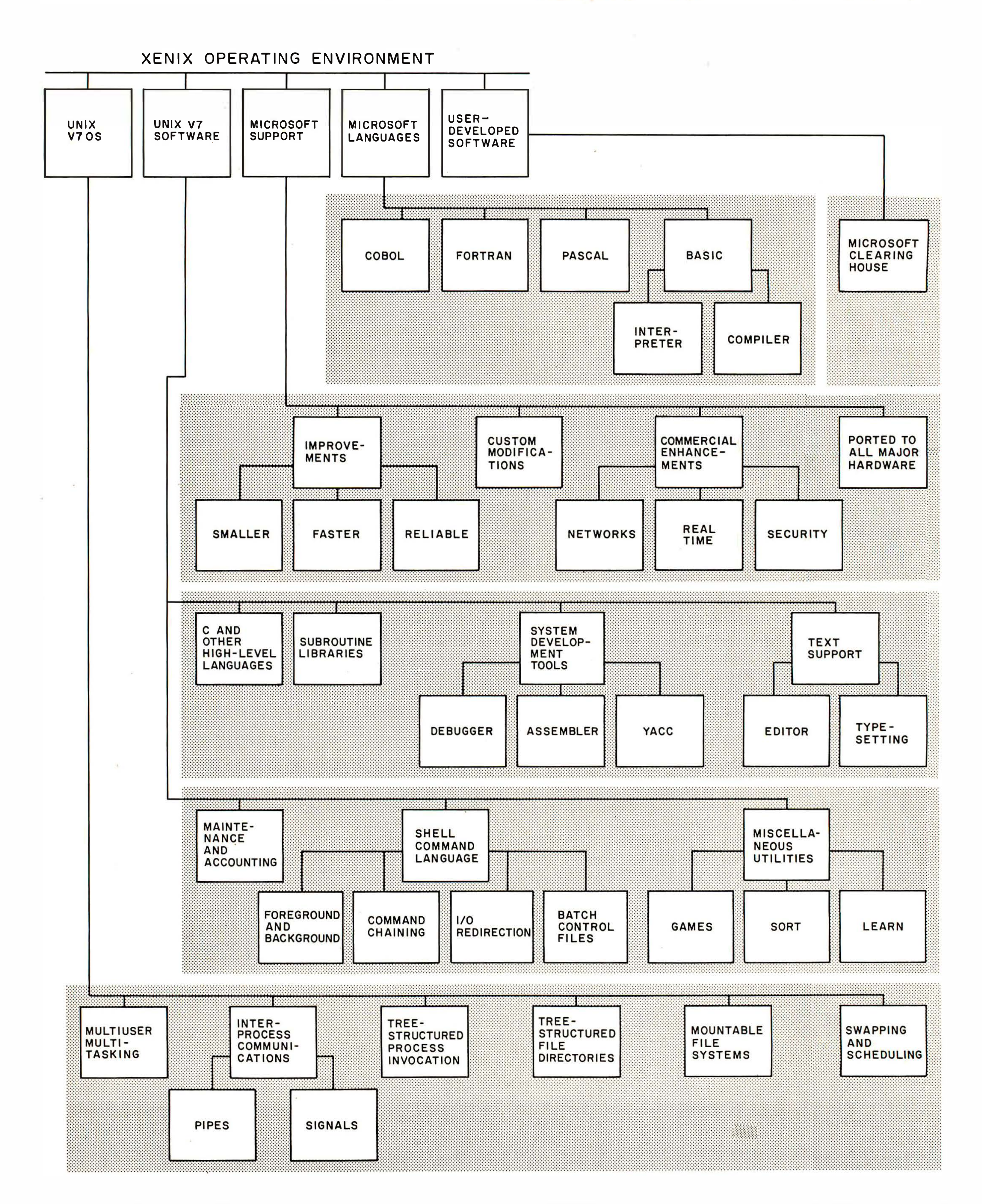


Figure 1: *Microsoft's XENIX operating system. The five "layers" of the XENIX software structure are shown. XENIX, a superset of Bell Laboratories' UNIX operating system developed in the early 1970s, has a hierarchical structure. Each of the five layers depends on the layers beneath it for its operation. The bottom two layers represent the latest version of UNIX (version 7). The remaining three layers are the refinements that combine to make the XENIX system.*

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creation of a UNIX users' organization, later called USENIX.

The first public release of the UNIX operating system, labeled version 5, was an unpolished snapshot of a research project that was still evolving. It was replaced in 1975 with version 6, a system that is still operating today at many sites. UNIX continued to evolve, benefitting from the feedback it received from scores of internal and external test sites.

In January 1979, Western Electric released version 7. By this time, hundreds of man-years' effort has been expended on UNIX's design and software utilities, with most of the system coded in C. Research had proven that UNIX was compatible with the concepts of memory-limited computers, machine transportability, networks, and multiple-processor designs.

Unfortunately, there was no single standard design for UNIX. Because the operating system was simple and easy to change, almost every site altered it to meet their specific needs. Harvard, the University of California at Berkeley, and the RAND Corporation each offered a set of modifications. A number of incompatible versions of UNIX existed within Western Electric.

In addition, there has been a legal impediment to the UNIX system's distribution. The system is available essentially free-of-charge for educational institutions. Legally, however, Western Electric cannot be in the software business, so the commercial world is offered the operating system under noncompetitive terms: source code as is and no warranty, support, or maintenance—a steep fee for software that was never intended to serve commercial applications outside of Western Electric.

It had become clear that the support of a commercial software company was essential if UNIX was to become a software standard. In August of 1980, Microsoft announced that it would offer and support XENIX, a commercial version of the operating system, on 16-bit microprocessors. Working closely with Western Electric and a newly formed commercial users' organization, Microsoft intends to establish a standard industry version of UNIX that can provide a highly productive environment worthy of meeting the challenges of software development in the 1980s.

UNIX Design Goals

Two aspects of UNIX's origin have contributed to its design: (1) it was created in a few man-years by two people, and (2) the implementers were also major users of the system. The result is a polished, consistent, coherent design. UNIX achieves great power and flexibility, including compatible interfacing between all its features, without resorting to a large, complex program. An experienced system programmer can understand the entire operating system in weeks, rather than months.

The UNIX system's design goals unite various features supported by the UNIX sytem into a consistent and simple whole. The first design goal is to support a very basic level of functionality within the operating system itself, relying on normal user programs to provide sophistication. Such features as line printer queuing, login/logout, monitor commands, and file access methods are implemented as normal user programs instead of operating-system functions. This approach, which reduces the overall complexity of the system, has several advantages. Functions are more modular, and therefore easier to debug, features can be altered and upgraded without stopping the operating system, and alterations made to one feature are less likely to affect the rest of the system. Finally, individual users may create personal versions of certain features.

The second design goal is generality—that is, having a single method serve a variety of related purposes. For example, the same system calls are used to read and write disk files, devices, and interprocess message buffers. Likewise, the same naming, aliasing, and access protection mechanisms apply to data files, directories, and devices. As a final example, the same mechanism is used to trap software interrupts, user abort requests, and processor traps. The benefits of generality extend well

beyond the simplicity of design; UNIX programming style is notably flexible, extensible, easily learned, and easily debugged.

The third goal is to accomplish large tasks by combining several small tasks whenever possible. UNIX's filters are an excellent example. A filter is a program that processes a single stream of input to generate one output stream. The UNIX system has a large variety of filters, including those that perform multicolumn formatting, string replacement, text processing, character translation, sorting, and graphics interfacing. Programs that generate output, such as the assembler, do not include facilities for listings; this task is accomplished by feeding programs directly to the various filters. This keeps the large programs simple to use, lets a user learn about each filter separately, and allows for special combinations of formatting without multiplying the options that each program would then have to support. It also leads to a uniform appearance of formatted output and the commands needed to produce it, and yields all the benefits of modular solutions to complex problems.

The vast number of utilities provided with the system and the ease of linking them together via pipes provide a surprising amount of functionality. For example, to find out how many people are currently using the system, you need only feed the output of the system "who" command to the utility that prints the number of lines in its input. Thus, the command line:

```
who | wc -l
```

causes the output of the who command, which might look like:

```
arw      console   Jan 30 14:20
bobg     tty00     Jan 30 01:00
henry    tty01     Jan 30 12:50
gordon   tty03     Jan 29 10:08
```

to be fed to the program "wc," for "word count." The −l option tells wc, which normally prints the number of characters, words, and lines in a file, that we only want to see the number of lines. Thus, this composite command prints a number which is the number of users on the system:

```
>who | wc -l
4
>
```

As a final step, we can create a file called "users," which contains the line:

```
who | wc -l
```

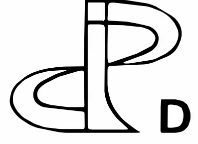
Typing "users" causes the command interpreter (or shell) to execute that line, and type the number of current users. We have now created a new system command.

A more dramatic example is shown in the following sequence: take a program that puts each text word in a file (or files) onto a separate line. Connect the output to a program that sorts lines into alphabetical order.

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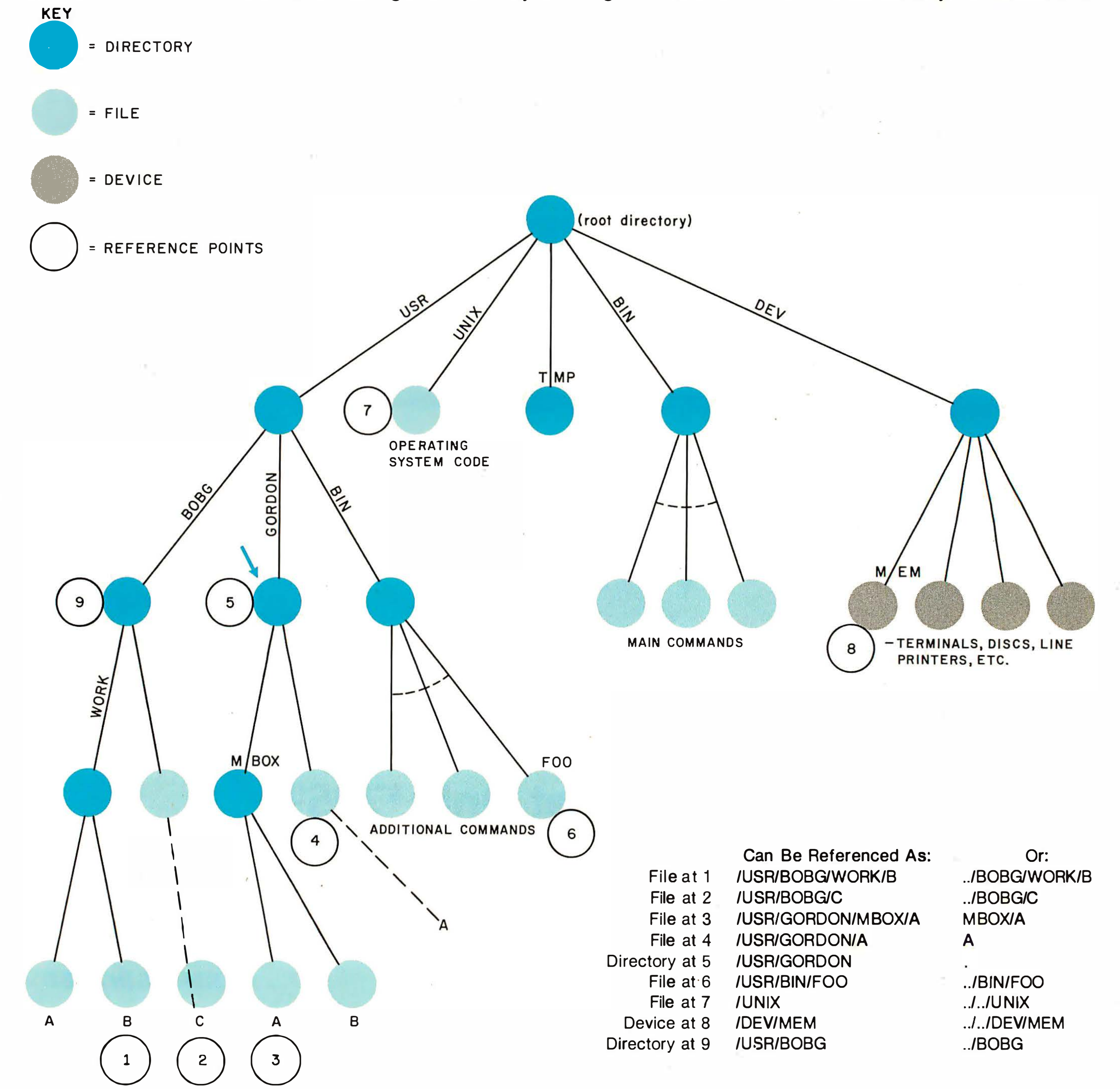
The output is a sorted list of all words in the text file(s). This list is fed to the program "uniq", which removes adjacent duplicate lines. The result is a data stream that contains one line for each different word in the original file(s). This stream is in turn connected to a program that reports differences between two files (one file being a list of 30,000 words from the dictionary). Thus, typing the line:

```
prep file | sort | uniq | comm wdlist
```

will result in a list of words present in "file" but not present in "wdlist". Without writing a line of code, you have created a simple spelling program! Now, by creating a file called "spell", which contains the line:

```
prep $* | sort | uniq | comm
/usr/dict/words
```

you have created the command "spell". Note that the "$*" is replaced by the command line interpreter with the arguments typed to the spell command. The UNIX sytem's command



	Can Be Referenced As:	Or:
File at 1	/USR/BOBG/WORK/B	../BOBG/WORK/B
File at 2	/USR/BOBG/C	../BOBG/C
File at 3	/USR/GORDON/MBOX/A	MBOX/A
File at 4	/USR/GORDON/A	A
Directory at 5	/USR/GORDON	.
File at 6	/USR/BIN/FOO	../BIN/FOO
File at 7	/UNIX	../../UNIX
Device at 8	/DEV/MEM	../../DEV/MEM
Directory at 9	/USR/BOBG	../BOBG

Figure 2: *Hierarchical structure of the names and conventions for getting to any reference point in a typical XENIX file structure. In this example, it is assumed that the user is at reference point 5 (blue arrow). A list of instructions for getting to the various reference points appears beneath the diagram. (The file and directory labels shown here are actual labels used in the author's system.) To get to file 1, the user types "/USER/BOBG/WORK/B". XENIX then progresses down the tree from the root directory (at top) to the branches USR, BOBG, WORK, and B, arriving at point 1. Alternatively, the user can use the command "../BOBG/WORK/B", where ".." refers to the parent node of the node currently in use. In XENIX, "." refers to the node itself.*

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interpreter, the shell, is a fully interactive language in its own right.

UNIX Operating System Design

The UNIX design introduces few new concepts because it borrows heavily from the better aspects of previously existing systems. UNIX contains numerous features found in the MULTICS and AOS operating sytems, and the language C is modeled after BCPL. However, the coherence and simplicity with which the chosen features interact result in an unusually elegant design that has great merit of its own.

The UNIX operating system supports a multiuser, multitasking environment. Each user has full access to the resources of the computer on a timesharing basis. UNIX implements scheduling and swapping algorithms that allow the processor and memory to service more tasks, seemingly simultaneously, than would otherwise be possible. UNIX also includes various protection schemes that protect each user from the others. This functionality contrasts markedly with the current microcomputer systems that simplify hardware operation by providing device drivers but make little attempt to extend the computer's utility.

The UNIX file system is a recursive structure originating from a *root directory*. The root directory contains the names of files and subdirectories; the subdirectories contain names of other files and additional subdirectories, etc. When a user logs into the system, he is assigned a specific subdirectory as his current working directory. Full path names for files consist of a possibly null sequence of subdirectories separated by a slash, beginning with either the root or the current working directory, and followed by the file name. By convention, the file in each subdirectory called ".." refers to the parent directory (see figure 2). Thus the user has a concept of local and global files neatly organized into directory groupings.

File names refer to data files, the directories themselves, character devices such as user terminals, block devices such as magnetic tape, file systems mounted onto other disk devices, and interprocess communications devices known as *multiplexed pipes*. Multiple names (called aliases) can be assigned to any of these objects. A set of information, including owner and access permissions, is stored with each object; the directory entries only specify names for the objects.

Programs communicate with their environment with read and write calls directed to a set of open files. Each program starts with three open files: *standard input*, *standard output*, and *error output*. Normally, these files are connected to the user's terminal, but a powerful command-language program, the shell, allows easy and invisible reassignment of these channels. A program can also open any other object (file, device, etc) named in the file system to which it has appropriate access permission. Using a special call, a program can create pipes, data channels that allow for communication between the program and any other programs connected to an end of the pipe.

All I/O (input/output) operations are performed as byte streams, with all channels appearing to contain a sequence of bytes until a globally defined end-of-file condition is indicated. Random access is also supported, using a call to reposition within the stream. Neither record sizes nor file types are imposed by the operating system. The system handles all interrupts and buffering, and each I/O call is suspended until the requested I/O operation can be completed. All devices, files, and pipes are treated identically (with minor exceptions), which greatly simplifies I/O routines.

A program may initiate another program by issuing a system call to duplicate itself. The two programs then operate independently, with

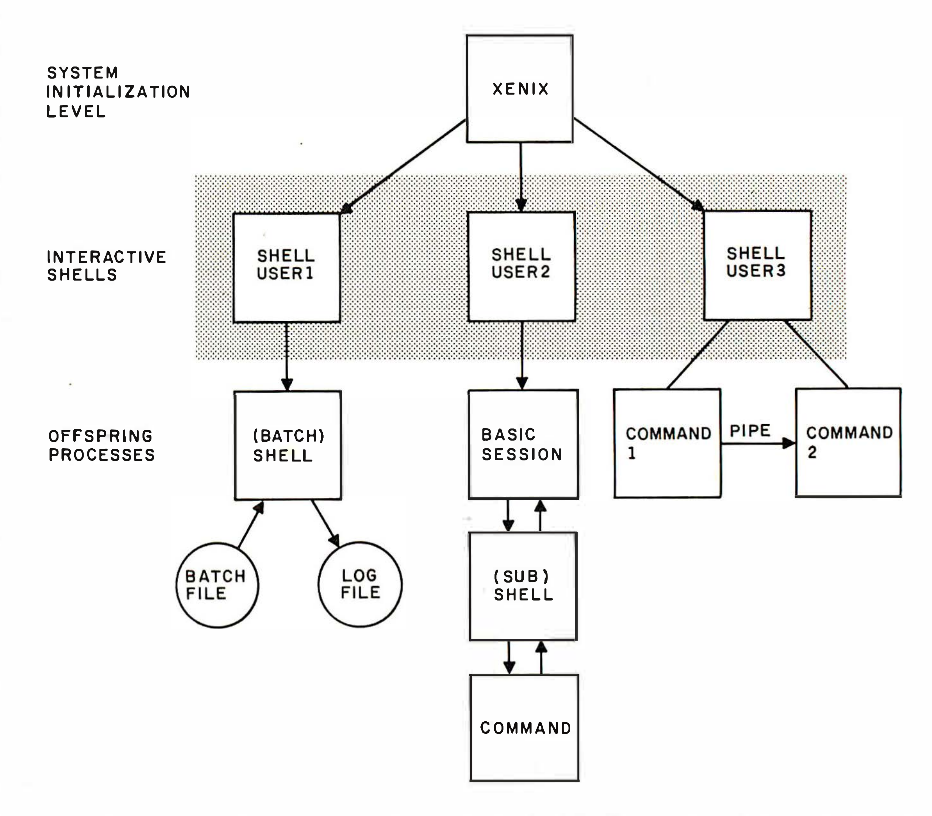


Figure 3: *Tree-structured process hierarchies in the XENIX system. Three users are currently on line. The term "shell" refers to that portion of the XENIX operating system program that "surrounds" the operating system and allows it to communicate with the outside world. User 1 is running a batch shell that is executing commands from a file. User 2 has suspended a BASIC session and entered a subshell to issue a command at the system-monitor level, perhaps to send a message to another user. User 2 can then return to BASIC and resume the session. User 3 has executed a command whose output is piped through a second command.*

UNIX timesharing between them (see figure 3). Typically, the parent process waits for the completion of its child, and the child process executes another program in the file system by issuing a system call. However, both programs may continue execution in parallel. To synchronize their operation, they can communicate via the file system, pipes, or signals. Signals are software asynchronous interrupts that are issued by one program to another to cause the second program to interrupt its execution, process the signal, and then resume normal execution. Signals are also generated by user interrupt requests and software failures, such as divide-by-zero.

Thus, when a user compiles and links a program test.c by typing:

```
>cc test.c
```

the shell runs the C compiler (cc) as a child process. After it has spawned the child process, the shell puts itself to sleep. When the child process (the C compiler) finishes, the shell awakens and issues another prompt. However, by simply adding an ampersand character to the command line:

```
>cc test.c &
```

you can instruct the shell not to sleep, but rather to return immediately for another command. You can then edit your documenation or some further program, while the first one is compiling. Note that typing:

```
>filename
```

causes the shell to run a copy of itself as a child. This child shell then executes, one by one, the commands in "filename." By simply adding the "&" character to the following line:

```
>filename &
```

you now have the capabilities of a full batch system, for free, as a result of the UNIX system's flexibility.

This section has presented a brief overview of the UNIX system features. A more complete description is available in documents from Microsoft, Western Electric, and a number of universities. I will conclude this section with a discussion of an excellent example of UNIX's multitasking abilities.

Multitasking

The multitasking and interprocess communication features of the UNIX system provide power that is unavailable in existing 8-bit computer systems. RITA, a large interpreter language for UNIX that I helped create for the RAND Corporation, provides an extensive example of the utility of these features. The RITA interpreter consists of over 100 K bytes of instructions and more than 64 K bytes of data—much larger than the current limit on UNIX program size. The solution was to split RITA into three separate programs that communicate though the use of five pipes, as illustrated in figure 4. Furthermore, separate programs are created by the interpreter to edit programs, read RITA news files, and perform UNIX commands, such as obtaining

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access to networks. Several files are written for analysis by still other programs. All this multitasking takes place invisibly: the user still thinks he or she is running a single program.

A further benefit of multitasking and device-independent I/O is an unexpected feature of RITA's three-program arrangement. Normally, the first program, UFE (user front end) allows you to type and edit program statements, which are then converted to internal form by the second program, the parser, which in turn stores them in the third program, the monitor, for evaluation. The UFE also allows the statements to be entered from a disk file; however, due to the complex parser program, loading a large file is too time consuming for many applications. A slight alteration to the UFE, the program which creates the other two programs and the five pipes, provides the solution. The new UFE (now called RC for RITA compiler), which requires no changes to the parser or monitor, funnels the output of the parser, normally fed to a pipe, into a disk file. Thus, RC produces "compiled" files whose contents can be fed directly into the monitor, bypassing the parser, when later loaded by RITA's UFE.

An Assessment of UNIX

UNIX offers unparalleled power for such a straightforward system. For the programmer, the system is easy to learn and offers immediate functionality, even for beginners. For more experienced users, the wealth of software tools leads to a more productive environment than less complete systems.

In addition, the UNIX operating system comes with hundreds of utilities and software tools that make it a complete software development environment. There is software for accounting, text editing, formatting and typesetting, high-level languages,

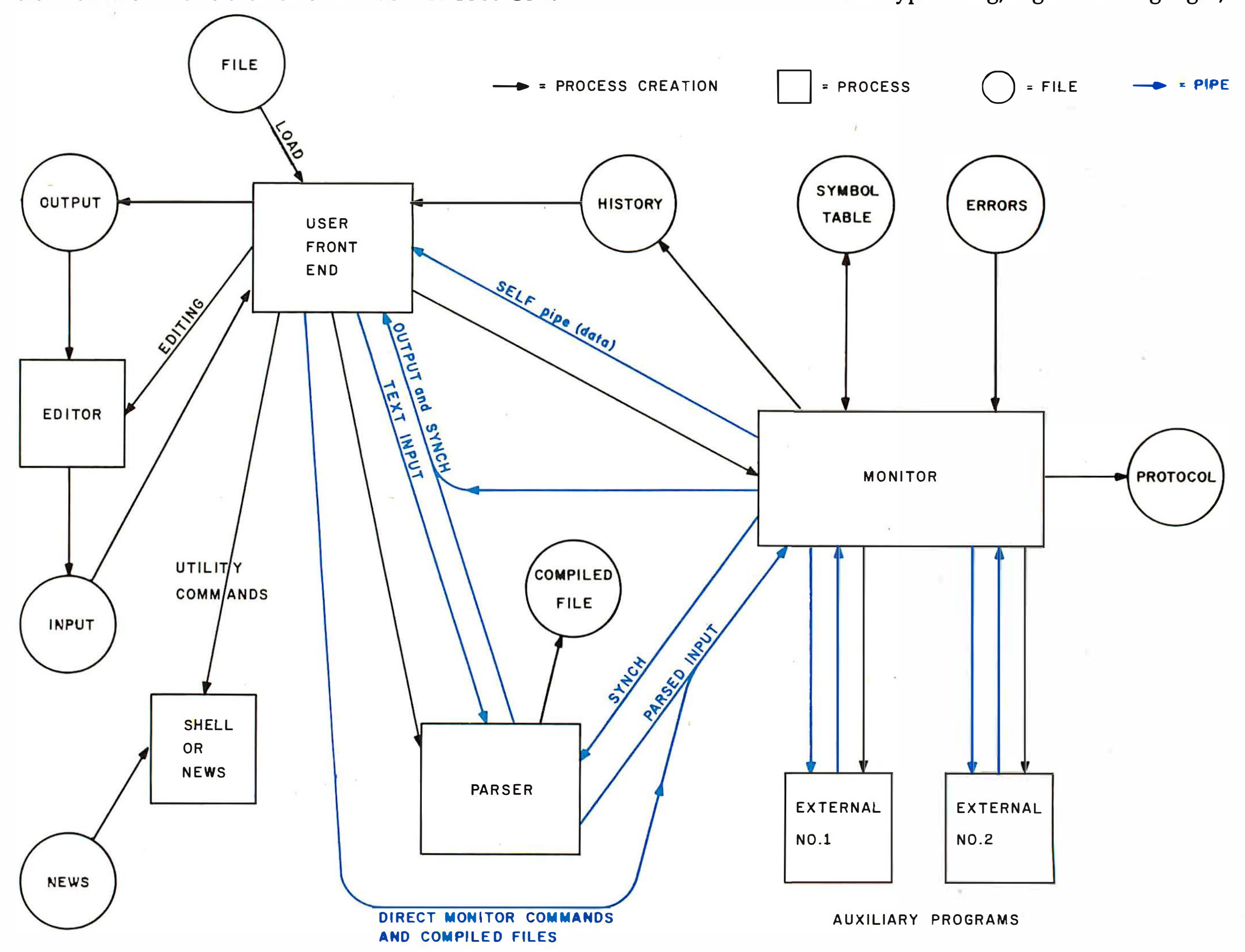


Figure 4: *RITA, a program designed in part by the author to illustrate the multitasking and interprocess communication features of the UNIX system. The RITA interpreter consists of over 100 K bytes of instructions and more than 64 K bytes of data: much larger than the current limits on UNIX program size. The solution to the problem is to split RITA into three separate programs that communicate through the use of five "pipes." A different UFE (user front end) program, called the RITA compiler, can refunnel the output of the parser, normally fed to the monitor, into a disk file. Thus, the RITA compiler produces "compiled" files whose contents can be fed directly into the monitor, bypassing the parser, when later loaded by RITA's user front end. This approach allows the user to load large files that might otherwise require too much time.*

TRS-80* COMPUTING EDITION

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Percom's DOUBLER II® tolerates wide variations in media, drives

GARLAND, TEXAS — May 22, 1981 — Harold Mauch, president of Percom Data Company, announced here today that an improved version of the Company's innovative DOUBLER® adapter, a double-density plug-in module for TRS-80* Model I computers, is now available.

Reflecting design refinements based on both theoretical analyses and field testing, the DOUBLER II®, so named, permits even greater tolerance in variations among media and drives than the previous design.

Like the original DOUBLER, the DOUBLER II plugs into the drive controller IC socket of a TRS-80 Model I Expansion Interface and permits a user to run either single- or double-density diskettes on a Model I.

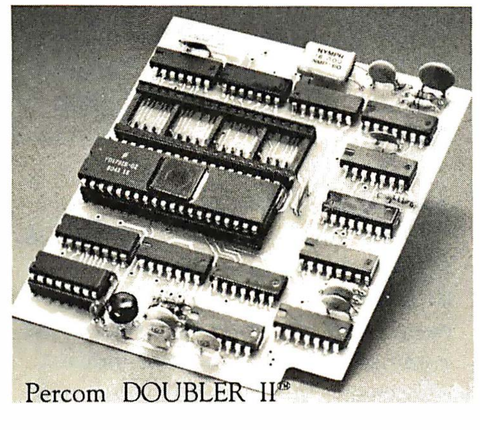
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Moreover, a DOUBLER II equips a Model I with the hardware required to run Model III diskettes.

(*Ed. Note:* See "OS-80®: Bridging the TRS-80* software compatibility gap" elsewhere on this page.)

The critical clock-data separation circuitry of the DOUBLER II is a proprietary design called a ROM-programmed digital phase-lock loop data separator.

According to Mauch, this design is more tolerant of differences from diskette to diskette and drive to drive, and also provides immunity to performance degradation caused by circuit component aging.



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Mauch said "A DOUBLER II will operate just as reliably two years after it is installed as it will two days after installation."

The digital phase-lock loop also eliminates the need for trimmer adjustments typical of analog phase-lock loop circuits.

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The DOUBLER II also features a refined Write Precompensation circuit that more effectively minimizes the phenomena of bit- and peak-shifting, a reliability-impairing characteristic of magnetic data recording.

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The DOUBLER II sells for $219.95, including the DBLDOS diskette.

Owners of original DOUBLERs may purchase a DOUBLER II upgrade kit, without the disk controller IC, for $30.00. Proof of purchase of an original DOUBLER is required, and each DOUBLER owner may purchase only one DOUBLER II at the $30.00 price.

The Percom DOUBLER II is available from authorized Percom retailers, or may be ordered direct from the factory. The factory toll-free order number is 1-800-527-1592.

Ed. note: Opening the TRS-80 Expansion Interface may void the Tandy limited 90-day warranty.

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Circuit misapplication causes diskette read, format problems.
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The problem is most severe on high-number (high-density) inner file tracks.

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The Percom solution is a simple adapter that plugs into the drive controller of the Expansion Interface (EI).

Not a kit — some vendors supply an untested separator kit of resistors, ICs and other paraphernalia that may be installed by modifying the computer — the Percom SEPARATOR is a fully assembled, fully tested plug-in module.

Installation involves merely plugging the SEPARATOR into the Model I EI disk controller chip socket, and plugging the controller chip into a socket on the SEPARATOR.

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Ed. note: Opening the TRS-80 Expansion Interface may void the Tandy limited 90-day warranty.

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All that glitters is not gold
OS-80®: Bridging the TRS-80* software compatibility gap

Compatibility between TRS-80* Model I diskettes and the new Model III is about as genuine as a gold-plated lead Krugerrand.

True, Model I TRSDOS* diskettes can be *read* on a Model III. But first they must be converted and re-recorded for Model III operation.

And you *cannot write* to a Model I TRSDOS* diskette. Not with a Model III. You cannot add a file. Delete a file. Or in any way modify a Model I TRSDOS diskette with a Model III computer.

Furthermore, your converted TRSDOS diskettes cannot be converted *back* for Model I operation.

TRSDOS is a one-way street. And there's no retreating. A point to consider before switching the company's payroll to your new Model III.

Real software compatibility should allow the *direct, immediate* interchangeability of Model I and Model III diskettes. No read-only limitations, no conversion/re-recording steps and no chance to be left high and dry with Model III diskettes that can't be run on a Model I.

What's the answer? The answer is Percom's OS-80® family of TRS-80 disk operating systems.

OS-80 programs allow *direct, immediate* interchangeability of Model I and Model III diskettes.

You can run Model I single-density diskettes on a Model III; install Percom's plug-in DOUBLER® adapter in your Model I, and you can run double-density Model III diskettes on a Model I.

There's no conversion, no re-recording.

Slip an OS-80 diskette out of your Model I and insert it directly in a Model III.

And vice-versa.

Just have the correct OS-80 disk operating system — OS-80, OS-80D or OS-80/III — in each computer.

Moreover, with OS-80 systems, you can add, delete, and update files. You can read *and write* diskettes regardless of the system of origin.

OS-80 is the original Percom TRS-80 DOS for BASIC programmers.

Even OS-80 utilities are written in BASIC.

OS-80 is the Percom system about which a user wrote, in Creative Computing magazine, ". . . the best $30.00 you will ever spend."†

Requiring only seven Kbytes of memory, OS-80 disk operating systems reside completely in RAM. There's no need to dedicate a drive exclusively for a system diskette.

And, unlike TRSDOS, you *can* work at the track sector level, defining and controlling data formats — in BASIC — to create simple or complex data structures that execute more quickly than TRSDOS files.

The Percom OS-80 DOS supports single-density operation of the Model I computer — price is $29.95; the OS-80D supports double-density operation of Model I computers equipped with a DOUBLER or DOUBLER II; and, OS-80/III — for the Model III of course — supports both single- and double-density operation. OS-80D and OS-80/III each sell for $49.95.

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assembly support utilities, sorters and index generators, communication facilities, tools that create parsers and lexical analyzers, graphics, games, mathematical function libraries, maintenance and performance utilities, and a host of file manipulators. Few needs cannot be met through a combination of these existing utilities.

The flexibility of UNIX allows easy alteration of its user interface. Various installations have demonstrated how easy it is to completely alter the appearance of UNIX in order to serve a different class of users. That UNIX cannot be everything to everyone is overshadowed by the fact that, as it is truly general-purpose, it can perform in almost any environment.

UNIX, as supplied by Western Electric, is not without its weaknesses. The general-purpose timesharing design limits UNIX's efficiency in real-time applications, such as process control. Its standard interface is highly terse, and though this is often considered desirable by programmers, the untamed UNIX will frighten almost everyone else. The origins of many of the command names are obscure; examples include a tape command "r" to write to a tape, command "cat" which types files, and "awk", a program for finding patterns in files. However, command names can be easily changed by the user.

UNIX has not been adapted for commercial use, where the issues of reliability, stability during hardware errors, full per-user accounting, reconfigurability for a large variety of environments, and security take on special importance. For example, less expensive disk packs for larger disk drives usually contain bad spots, and UNIX does not automatically adjust for them. In the environment for which the UNIX system was developed, it was cheaper to buy perfect packs than to write a " bad spot avoidance" routine. These issues must be addressed before UNIX can be considered a sturdy, robust, and commercial piece of software.

A crucial problem, and one not restricted to UNIX, is the lack of true applications software. Currently, there are few good accounts payable, invoicing, mailing list, income tax, or data-base management packages. UNIX provides an excellent software production environment because of its wealth of software tools utilities, but the system does not contain a similar variety of application-oriented software.

The XENIX System

Microsoft's XENIX operating system represents an attempt to preserve the strengths of the UNIX design and also meet the needs of the commercial microprocessor industry. To achieve this goal, Microsoft used the system as it was distributed by Western Electric and then added modifications, customizations, improvements, enhancements, support, and additional software.

Modifications included those necessary to transport the UNIX system from the larger PDP-11 minicomputer to the 16-bit microprocessors. Currently scheduled machines include the DEC LSI-11/23, Zilog's Z8001 and Z8002, Intel's 8086 and 286, and Motorola's MC68000. Numerous other processors are also being considered, and Microsoft will then customize the XENIX systems to the specific hardware environments of the various computer systems built around these processors. The company is also working closely with a number of hardware manufacturers to design products that will be capable of efficiently executing the XENIX software.

Improvements will include elimination of known bugs and recoding of certain routines to produce a smaller and faster operating system. XENIX will also incorporate hardware error recovery strategies, automatic file repair after crashes, power-fail and parity-error detection, and similar features, depending on the particular hardware requirements of each XENIX system.

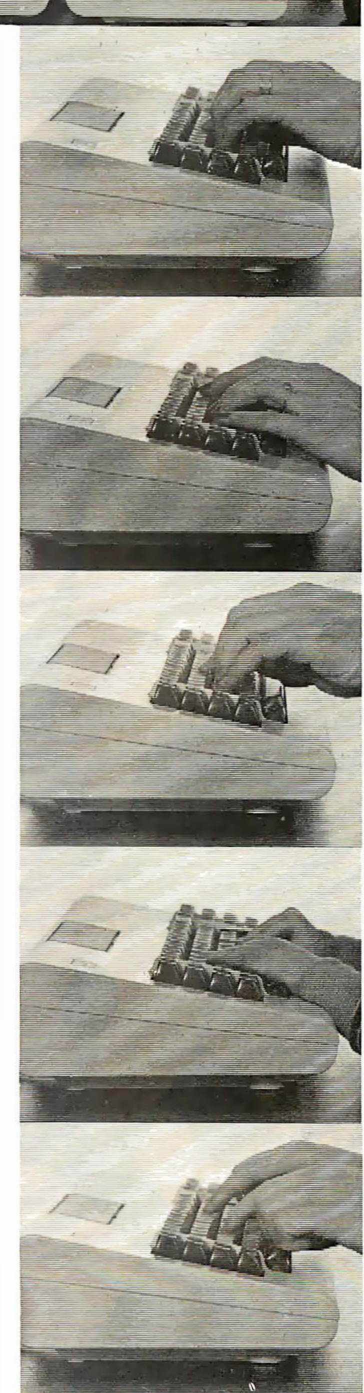
The planned enhancements will add a number of new features to XENIX. These features include record locking, shared data segments, synchronous writing, and improved interprocess communication—all of which are designed to make XENIX commercially viable and more compatible with the newer hardware technologies that involve distributed data processing, networking, and multiple-CPU approaches.

XENIX is a dynamic, evolving system. In its first release, its code was very close to the original UNIX version 7 source. The improvements and enhancements that I have mentioned are part of an evolving process, and the exact selection and specification of features will be developed throughout the course of 1981. Updates to XENIX will result in systems upwardly compatible from its first release.

The adaptation of Microsoft's full line of system software products to XENIX will further strengthen XENIX's role as a software standard. These products, including the BASIC interpreter and compiler, COBOL, FORTRAN, and Pascal, have already established themselves as standards within the 8-bit market; they are also compatible with corresponding ANSI (American National Standards Institute) standards. Standard high-level languages will allow the rapid introduction of existing application software into the XENIX environment.

The XENIX system will offer an ever-expanding variety of software, including data-base management, financial planning, communication, and networking packages. Microsoft is establishing a clearinghouse, wherein quality software running under XENIX may receive widespread distribution, thereby reducing duplication of effort. The combination of the UNIX operating system's strengths and Microsoft's awareness of the needs of the commercial marketplace promises to make XENIX a very powerful defense against the looming software crisis. By establishing a universal operating environment, complete with software tools to increase productivity, flexible design to widen applicability, and multiple microprocessor support to improve availability, Microsoft hopes that XENIX will become the preferred choice for software production and exchange.■

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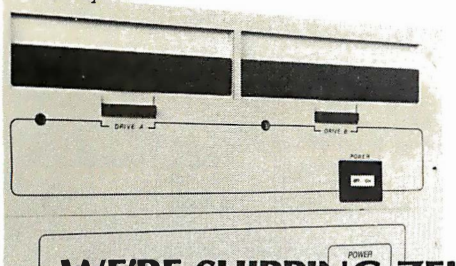
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- MUSE supports standard CP/M* word processors, utilities, and languages: MBASIC, CBASIC, PASCAL, FORTRAN, COBOL, FORTH, C, PL/1, etc.

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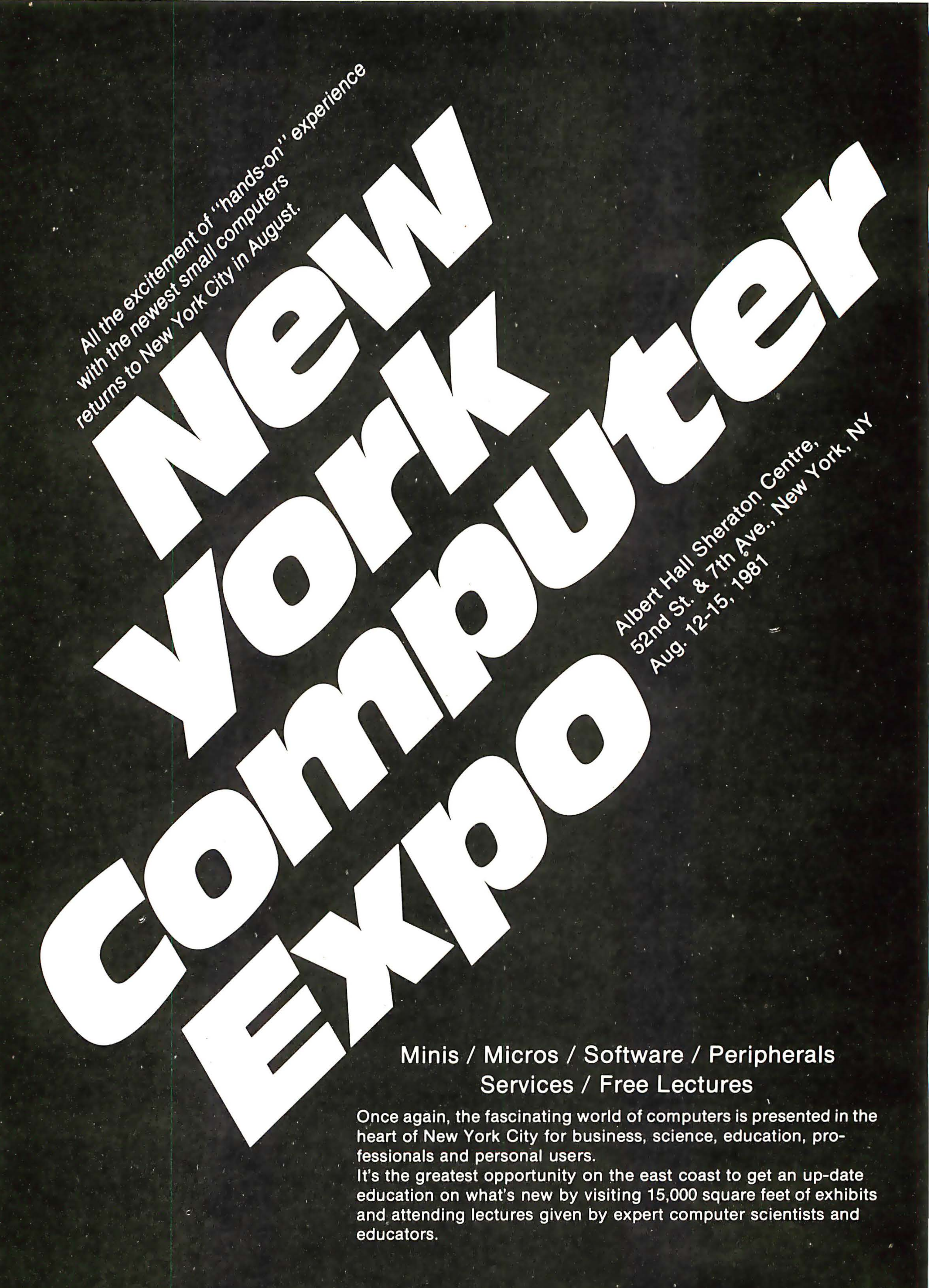
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-Memory--RAM, ROM, EPROM, ETC.
-Peripherals.
C. Computer Software
-The anatomy of a simple computer language--BASIC.
-Software buzzwords.
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The Ins and Outs of CP/M

James Larson
3422 Union St
San Diego CA 92103

CP/M (Control Program for Microprocessors) is the most commonly used 8080/8085/Z80 operating system. CP/M is easy to use and the Digital Research documentation is reasonably thorough and clear, especially by microprocessor-software standards. However, the documentation is lacking in one area: the explanation of I/O (input/output) and disk interfacing. This article will clarify and expand upon the documentation. A summary of the I/O and disk-interface routines, calling sequences, use of return codes, and typical subroutines using these will be presented. The use of file-control blocks (FCBs) and I/O buffers will also be explained. Finally, some details of the CP/M I/O functions and their workings will be presented.

Calling CP/M Routines

The procedure for calling CP/M routines is straightforward. I/O procedures are defined as a series of functions. Each function is assigned a unique *function number*. The function number is placed in the microprocessor's C register; the data required (*entry parameter* in CP/M parlance) is placed in the E register if only 1 byte is to be sent, or in the DE register pair if a word (2 bytes) is required. Some functions have no entry parameters. Results (called *returned values*) are either returned as a byte in the A register or as a filled buffer (whose address is usually sent as an entry parameter). Table 1 summarizes the basic I/O functions and calling sequences. Once the registers are properly loaded, a call to the CP/M entry point at hexadecimal memory location 0005 is made. It is important to know that CP/M does not preserve the contents of these registers, so any routine calling CP/M routines must protect any registers to be preserved. A typical subroutine to call a CP/M-utility routine is shown in listing 1. Refer to the examples for specific applications of this sequence. The function numbers and their purpose, entry parameters, and returned-value codes are summarized in table 1 and table 2.

I/O Routines

Listing 2 presents several useful subroutines that make calls to CP/M I/O routines. Calls to the punch device and reader device assume that these drivers exist in your version of CP/M, though they may or may not actually be driving a physical paper-tape reader/punch. As explained in the *CP/M Features and Facilities Guide*, logical devices may or may not correspond to actual physical devices. Writing and installing these drivers for CP/M is beyond the scope of this article.

Listing 3 shows the use of buffers for CP/M I/O. The address of the buffer is placed in the DE register pair and the call to the CP/M entry point is made. The contents of the print buffer are printed on the console until a dollar sign is encountered. The print buffer is not destroyed in this process. A typical print buffer is configured as:

c1 c2 c3 c4 .... *ck* $

where *k* is the number of valid characters and $ signifies the end of the buffer. The read buffer is configured as:

m *k* c1 c2 c3 c4 .... *ck*

where *m* is the maximum number of characters allowed in the buffer, and *k* is the number of characters actually in the buffer. CP/M places characters in the buffer until a carriage return is encountered or the maximum buffer length is reached. The maximum length, *m*, may be from 1 to 256, and is defined by the user program. The value of *k*, the number of valid characters, is initially set to 0. It is set by CP/M to reflect the number of

LEADER OF THE PACK



Circle 35 on inquiry card.

characters read into the buffer from the console. The CP/M line-editing features (control R, control C, etc) may be used with this routine. Other control characters will be echoed with a leading ^ (called a circumflex), and will be inserted into the buffer. Any parity bits will be stripped by CP/M (this also applies to the single-character read functions in listing 2).

The final aspect of CP/M I/O that requires clarifying is the I/O status byte. This is a single byte at hexadecimal memory location 0003. It was apparently included in CP/M for compatibility with Intel software and must be specifically implemented by the user in BIOS (Basic I/O System). The I/O status byte, poorly described in the *Interface Guide*, is described much better in the *System Alteration Guide*, Section 6. By varying the value of this location, the user may reassign logical I/O devices without rewriting the system software.

CP/M Disk-Interface Routines

The use of the disk-interface routines provided by CP/M is more involved. But it is not too difficult once the basic concepts are grasped.

Text continued on page 274

Function Number	Function Description	Entry Parameters (placed in DE)	Returned Value (Returned in A or AB (A = LSB))	Typical Call **		
1	Read a character from the console.	None	ASCII character	MVI CALL	C,1 NTRY	;READ FUNCTION ;CP/M ENTRY POINT
2	Write a character to the console.	ASCII character	None	MVI MVI CALL	E,CHAR C,WRITE NTRY	;CHARACTER IN E ;WRITE FUNCTION = 2
3	Read a character from the reader device.	None	ASCII character	MVI CALL	C,RDR NTRY	;READER FUNCTION = 3
4	Write a character to the punch device.	ASCII character	None	MVI MVI CALL	E,CHAR C,PNCH NTRY	;CHARACTER IN E ;PUNCH FUNCTION = 4
5	Write a character to the list device (usually a printer).	ASCII character	None	MVI MVI CALL	E,CHAR C,PRNT NTRY	;WRITE TO PRINTER = 5
7	Get I/O status.*	None	I/O status byte			
8	Set I/O status.*	I/O status byte	None			
9	Output print buffer to console.	Address of a print buffer	None	LXI MVI CALL	D,PBUF C,BUFO NTRY	;ADDRESS OF BUFFER ;OUTPUT BUFFER = 9
10	Input a character string from the console.	Address of a read buffer	The read buffer is filled to its maximum length or until a <CR> is typed.	LXI MVI CALL	D,RBUF C,BUFI NTRY	;ADDRESS OF BUFFER ;INPUT BUFFER = 10
11	Interrogate console for a character ready.	None	01 if a character is ready	MVI CALL	C,ASK NTRY	;INTERROGATE = 11

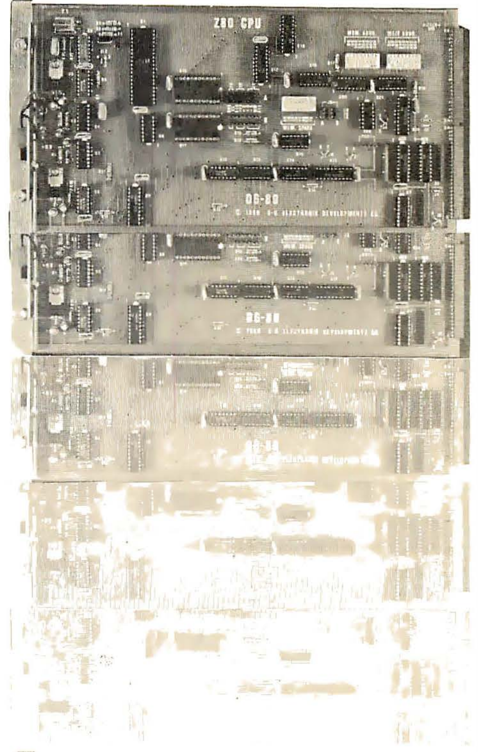
*If implemented

**See listings 1, 2, and 3 for subroutines and program usage. NTRY is the CP/M entry point (0005).

Table 1: *Summary of the basic I/O functions available on a standard CP/M system.*

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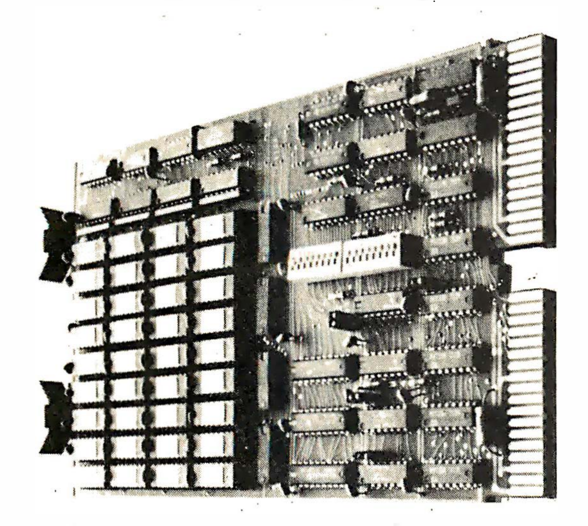
Circle 102 on inquiry card.

Function Number	Function Description	Entry Parameters and Comments (placed in DE)	Returned Value and Comments. (Returned in A or AB (A = LSB))	Typical Call*		
12	Lift head.	None	None—head is lifted from currently logged disk.	MVI CALL	C,12 NTRY	;LIFT FUNCTION ;CP/M ENTRY POINT
13	Initialize CP/M disk access.	None	None—disk drive A is "logged in" for access. The DMA address is set to 0080H.	MVI CALL	C,13 NTRY	;INITIALIZE
14	Select and log in disk.	Value corresponding to the desired disk: A = 0, B = 1, etc	None—specified disk is selected for subsequent file operations.	MVI MVI CALL	E,DISKNO C,SELDSK NTRY	;DISK # IN E ;SELECT = 14
15	Open file.	Address of FCB for the file to be opened	Byte address of the FCB in the disk directory, or 255H if file is not found—the disk map (DM) bytes in the FCB are filled by CP/M.	LXI MVI CALL	D,FCB C,OPEN NTRY	;ADDRESS IN DE ;OPEN = 15
16	Close file.	Address of FCB for the file to be closed	Byte address of the FCB in the disk directory, or 255 if not found—the disk map of the FCB is written to the directory, replacing any existing data for that file.	LXI MVI CALL	D,FCB C,CLOSE NTRY	 ;CLOSE = 16
17	Search for file.	Address of FCB containing name and type of file to search for. "?" matches any character.	Byte address of first FCB in directory that matches the name and type in the input FCB. If no match, 255H is returned.	LXI MVI CALL	D,FCB C,SEARCH NTRY	 ;SEARCH = 17
18	Search for next occurrence.	Address of FCB as in 17, but called after 17 before any other disk access	Byte address of next match. 255H if no additional match.	LXI MVI CALL	D,FCB C,SEARN NTRY	 ;SEARN = 18
19	Delete file.	Address of FCB of file to be deleted	None—FCB in directory is marked as deleted. (E5H is placed in ET field.)	LXI MVI CALL	D,FCB C,DEL NTRY	 ;DEL = 19
20	Read record.	Address of FCB containing a disk map. Normally as a result of opening the file (15) and setting NR to the record to be read.	0 = successful read 1 = read past logical end of file (^Z) 2 = reading unwritten data Data read is placed in memory at the DMA address (function 26).	LXI MVI CALL JNZ	D,FCB C,READ NTRY ERROR	 ;READ = 20 ;HANDLE READ ERROR
21	Write record.	Same as read, but NR is set to the record to be written	0 = successful write 1 = error in extending file 2 = end of disk data 255H = no more directory space—Data written is taken from memory starting at the DMA address.	LXI MVI CALL JNZ	D,FCB C,WRITE NTRY ERROR	 ;WRITE = 21 ;HANDLE WRITE ERROR
22	Create file.	Address of FCB of new file, all data set to 0 except name and type	Byte address of directory entry of new file or 255H if directory is full.	LXI MVI CALL JM	D,FCB C,CREATE NTRY NOROOM	 ;CREATE = 22 ;HANDLE FULL ; DIRECTORY
23	Rename file.	Address of FCB with old file name and type in first 16 bytes and the new file name in the next 16 bytes	Directory address of old file, or 255H if not found. The file name and type are changed to that specified.	LXI MVI CALL JM	D,FCB C,RENAM NTRY NOFILE	 ;RENAM = 23 ;HANDLE NOT FOUND
24	Interrogate disk log-in.	None	Byte with 1 bit set for each disk logged in. LSB = disk A, etc.			
25	Interrogate drive number.	None	Number of disk to be used for next access.			
26	Set DMA address.	Address of 128-byte buffer	None—subsequent reads and writes take data to/from memory beginning at this address.	LXI MVI CALL	D,BUFF C,26 NTRY	;BUFFER ADDRESS ;DMA SET FUNCTION
27	Interrogate allocation.	None	Address of the current disk-allocation data. (Used by STAT—not well documented.)			

*See listing 3 for subroutines and program usage.

Table 2: *Summary of disk-access operations and disk-utility functions available on a standard CP/M operating system.*

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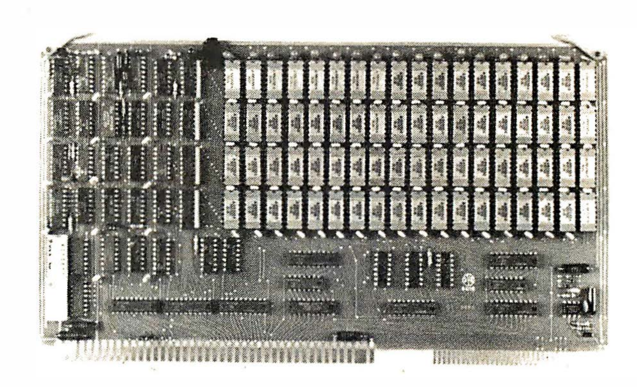
PARITY — The CI-8086 generates and checks even parity with selectable interrupt on parity error.

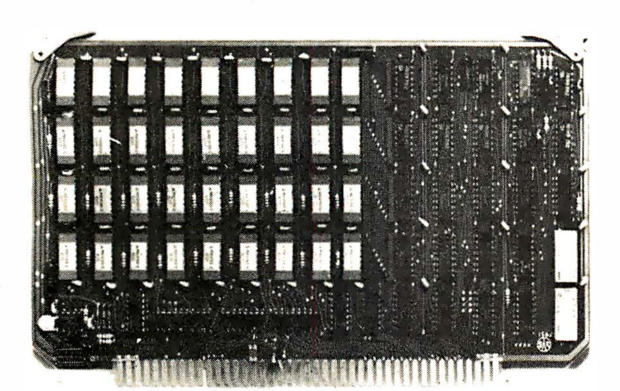
FAST ACCESS AND CYCLE TIME — Data access is 270 NSEC and cycle time is 375 NSEC.

16 MEGA BYTE ADDRESSING — The memory is addressable in 16K increments up to 16 mega bytes.

LOW POWER CONSUMPTION — Total power consumption is under 8 watts.

SINGLE QTY. PRICE: 128K x 9 **$1350.** 512K x 9 **$2995.**





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ADDRESSING — On-board memory select is available in 4K increments up to 64K words of memory on either the VUA or VXA control inputs.

PARITY — On board even parity with output jumper select to the system bus as a parity error or non-maskable interrupt.

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Circle 59 on inquiry card.

Text continued from page 270:

Proper use of these routines provides powerful capabilities for file manipulation, creation, and alteration. Tasks such as reading an application program into the proper region of memory, sending instructions with a file name, or detecting which disk drive a given file resides on (if any) are readily handled by CP/M. Let us see how these tasks may be accomplished.

Before a file can be manipulated by CP/M, its name must be made known to the system. This is done via the file-control block (FCB). A file-control block contains six types of information defined with 33 contiguous bytes in memory (0 to 32):

- Entry type (ET, byte 0)—assumed 0 by CP/M. CP/M places hexadecimal E5 here to signify a deleted file.
- File name (FN, bytes 1 to 8)—ASCII characters padded with ASCII blanks.
- File type (FT, bytes 9 to 11)—ASCII characters padded with ASCII blanks.
- File extent (EX, byte 12)—in 128-record segments. If file is longer than 128 records, this byte must be incremented to access the additional records. Normally, this will be initialized to 0.
- Initialize to 0 (bytes 13 to 14) —these bits may be used by some systems (such as Micropolis), but should not be tampered with.
- Record count (RC, byte 15)—current file size in 128-byte records. Initialized to 0—correct value will be supplied by executing the OPEN statement.
- Disk allocation map (DM, bytes 16 to 31)—this map is used by CP/M to access the desired file. It is written into memory by the OPEN command, updated during access, and written back to the directory by the CLOSE command. It is not necessary to initialize this area if OPEN is used.
- Next record (NR, byte 32)—this is the number of the next record to access in the currently open extent. Normally, this will be initialized to 0 unless random access is desired or a file is to have something appended to it.

Listing 1: *Structure of a typical function-calling routine. The CP/M operating system does not preserve the registers.*

```
IOSBR:  PUSH REGISTERS      ;PRESERVE REGISTERS. DO NOT PUSH REGISTERS
                             IN WHICH VALUES WILL BE RETURNED.
        MVI C,FUNCTION#     ;FUNCTION # MUST BE IN REGISTER C BEFORE
                             CALLING NTRY.
        MOV E,A             ;IF A CHARACTER IS TO BE OUTPUT, IT IS OFTEN
                             CONVENIENT TO SEND IT IN THE A REGISTER
                             (ACCUMULATOR). IT MUST BE MOVED TO E
                             BEFORE CALLING NTRY.
        CALL NTRY           ;CP/M ENTRY POINT, NTRY, MUST BE PREVIOUSLY
                             DEFINED AS 0005H.
        POP REGISTERS       ;RESTORE REGISTERS—BE SURE TO USE AS MANY
                             POPS AS YOU DID PUSHES.
        RET                 ;RETURN TO CALLING ROUTINE
```

File-control blocks are written to the directory by each CLOSE command; they are read by each OPEN command. They maintain the disk-file allocation map, size (in 128-byte records), and extent (in 128-record segments). A separate FCB is maintained in the directory for each extent of the same file (each extent contains 128 128-byte records). That is, a file of 158 records will have an entry with extent=0 and record count=128 and another entry with extent=1 and record count=30, both having the same file name and file type.

The system maintains a default FCB at hexadecimal location 005C and a default buffer at hexadecimal location 0080. These are used by CP/M to pass information to a user program. This is best explained by considering what happens when the program given in listing 4 is run. After it has been assembled and loaded, it is run by typing its name, as is any compiled program running under CP/M. However, in addition to its name, the name of the file to be processed and the desired options must be entered. For this example program, the file to be processed must have a file type .DEM . This file is read into memory beginning at the first free memory location after the end of the program. The options

Text continued on page 282

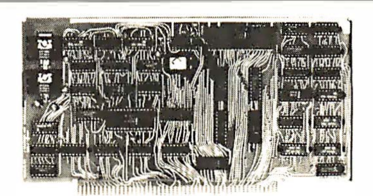
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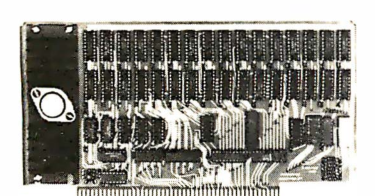
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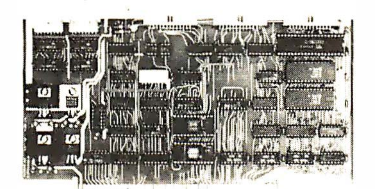
S-100 Boards



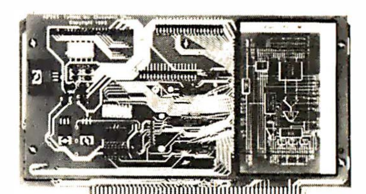
8086 CPU with Vectored Interrupts



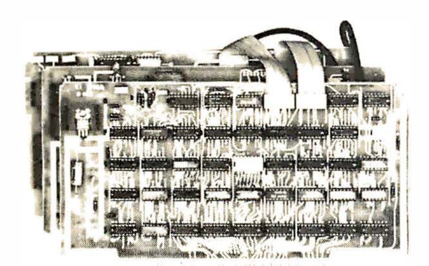
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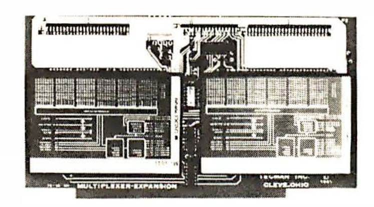
PROM and I/O
2 RS 232 - PIO
CP/M-86 ROM Boot



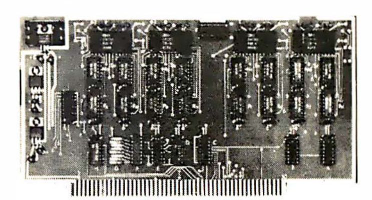
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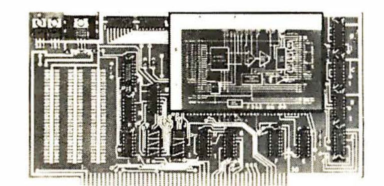
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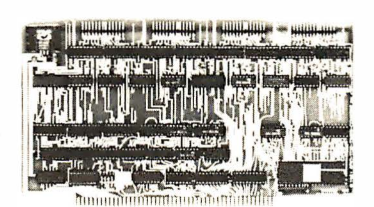
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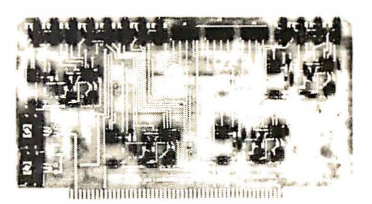
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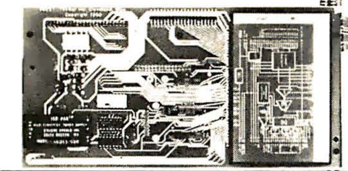


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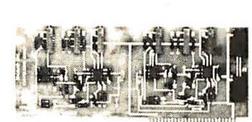
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Listing 2: *Examples of some simple I/O routines that utilize the CP/M I/O functions.*

```
;*****************************************************************************
;
;
;          SUBROUTINE RCHAR—READS A SINGLE CHARACTER FROM THE
;              CONSOLE. PLACES THE CHARACTER READ INTO THE
;              ACCUMULATOR (A REGISTER).
;
;*****************************************************************************
;
RFUNC      EQU     1             ;READ CONSOLE FUNCTION NUMBER
                                 ;REFER TO TABLE I OF INTERFACE
                                 ;GUIDE.
NTRY       EQU     0005H         ;CP/M NTRY POINT
RCHAR:     PUSH    H             ;PRESERVE REGISTERS
           PUSH    D
           PUSH    B
           MVI     C,RFUNC       ;PLACE CODE FOR READ FUNCTION
                                 ;IN C REGISTER
           CALL    NTRY          ;READ A CHARACTER
           MOV     A,E           ;MOVE CHARACTER JUST READ INTO
                                 ;A REGISTER.
           POP     B             ;RESTORE REGISTERS
           POP     D
           POP     H
           RET

;*****************************************************************************
;
;
;          SUBROUTINE WCHAR—WRITES A SINGLE CHARACTER TO THE
;              CONSOLE. ASSUMES THAT THE CHARACTER TO BE
;              WRITTEN IS IN THE A REGISTER.
;
;*****************************************************************************
;
WFUNC      EQU     2             ;CP/M FUNCTION NUMBER
WCHAR:     PUSH    H             ;PRESERVE ALL REGISTERS
           PUSH    D
           PUSH    B
           PUSH    PSW
           MOV     E,A           ;PLACE CHARACTER IN THE E
                                 ;REGISTER BEFORE CALLING NTRY
           MVI     C,WFUNC       ;PLACE FUNCTION NUMBER IN C
           CALL    NTRY          ;WRITE HIM
           POP     PSW           ;RESTORE REGISTERS
           POP     B
           POP     D
           POP     H
           RET

;*****************************************************************************
;
;
;          SUBROUTINE CLEAR—CLEARS THE SCREEN OF A SOROC IQ-120
;              TERMINAL. USES SUBROUTINE WCHAR TO SEND THE
;              CHARACTERS TO THE TERMINAL.
;
;*****************************************************************************
;
HOME       EQU     42            ;HOMES CURSOR AND CLEARS SCREEN
CLEAR:     PUSH    PSW           ;PROTECT STATUS FROM CALLING ROUTINE
           MVI     A,27          ;SEND ESCAPE CODE
           CALL    WCHAR         ;WRITE HIM
           MVI     A,HOME        ;CLEAR SCREEN AND HOME CURSOR
           CALL    WCHAR         ;WRITE AGAIN
           POP     PSW           ;RESTORE STATUS
           RET

******************************************************************************
```

Notice of Omission

Due to a processing error the Quantex Div. ad which appeared on page 329 of the May Byte had no Reader Service Number.

For more information regarding their "no problem trial offer" circle 470 on the inquiry card in this issue.

Listing 3: *Program to prompt for input, clear the screen, and echo the characters entered using the techniques discussed in this article. Except for the clear-screen codes, this routine works on any CP/M system.*

```
                    ;*****************************************************************
                    ;
                    ;     CP/M I/O UTILITIES PROGRAM
                    ;     WRITTEN BY JAMES K. LARSON
                    ;
                    ;*****************************************************************
                    ;
0100                        ORG     0100H
0100 C37302                 JMP     BEGIN   ;SKIP TO START OF MAIN ROUTINE
                    ;*****************************************************************
                    ;
                    ;     EQUATES AND DATA STORAGE AREA
                    ;
                    ;*****************************************************************
                    ;
0005 =              NTRY    EQU     0005H   ;CPM ENTRY POINT
0009 =              PSTR    EQU     9       ;PRINT BUFFER FUNCTION
000A =              GSTR    EQU     10      ;READ BUFFER FUNCTION
0002 =              WFUNC   EQU     2       ;WRITE CONSOLE FUNCTION
002A =              HOME    EQU     42      ;HOME CURSOR AND CLEAR
000D =              CR      EQU     13      ;CARRIAGE RETURN
000A =              LF      EQU     10      ;LINE FEED
0020 =              LEN     EQU     32      ;DESIRED OUTPUT LINE LENGTH
0103                OLDSTK: DS      2       ;OLD STACK POINTER
0105                STR:    DS      257     ;INPUT STRING BUFFER
0206 454E544552PROMPT: DW       'EN','TE','R$'
020C 594F552057LEADER: DW       'YO','U ','WR','OT','E$'
                    ;*****************************************************************
                    ;
                    ;    SUBROUTINE PRINT -- PRINTS A STRING ENDING IN $
                    ;        PLACE STRING BUFFER STARTING ADDRESS IN DE REGISTER
                    ;        PRESERVES REGISTER CONTENTS
                    ;
                    ;*****************************************************************
                    ;
0216 E5             PRINT:  PUSH    H       ;PRESERVE REGISTERS
0217 D5                     PUSH    D
0218 C5                     PUSH    B
0219 F5                     PUSH    PSW
021A 0E09                   MVI     C,PSTR  ;PRINT FUNCTION IN C REG
021C CD0500                 CALL    NTRY    ;DO IT
021F F1                     POP     PSW     ;RESTORE REGISTERS
0220 C1                     POP     B
0221 D1                     POP     D
0222 E1                     POP     H
0223 C9                     RET
                    ;*****************************************************************
                    ;
                    ;     SUBROUTINE GETBUF -- GETS A BUFFER FULL FROM CONSOLE
                    ;         PLACE INPUT BUFFER ADDRESS IN HL REGISTER - BUFFER
                    ;        SHALL HAVE THE FIRST BYTE SET TO THE MAXIMUM BUFFER
                    ;        LENGTH, THE NUMBER OF CHARACTERS PUT INTO BUFFER WILL
                    ;        BE RETURNED AS THE SECOND BYTE OF THE BUFFER.
                    ;
                    ;*****************************************************************
                    ;
0224 E5             GETBUF: PUSH    H       ;PRESERVE REGISTERS
0225 D5                     PUSH    D
0226 C5                     PUSH    B
0227 F5                     PUSH    PSW
0228 EB                     XCHG            ;PLACE ADDRESS IN DE FOR CALL TO CPM
0229 0E0A                   MVI     C,GSTR  ;READ BUFFER FUNCTION
022B CD0500                 CALL    NTRY    ;GET UM
022E F1                     POP     PSW     ;RESTORE
022F C1                     POP     B
0230 D1                     POP     D
0231 E1                     POP     H
```

Listing 3 continued on page 280

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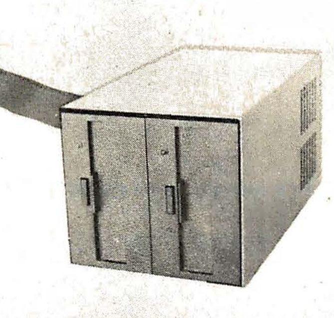
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Circle 370 on inquiry card.

Listing 3 continued:

```
0232 C9              RET
                ;*****************************************************************
                ;
                ;     SUBROUTINES WCHAR AND CLEAR FROM EXAMPLE 1 INSERTED HERE
                ;
                ;*****************************************************************
                ;
                ;*****************************************************************
                ;
                ;     SUBROUTINE WCHAR -- WRITES A SINGLE CHARACTER
                ;       CHARACTER IN A REGISTER - PRESERVES ALL REGISTERS
                ;
                ;*****************************************************************
                ;
0233 E5         WCHAR:  PUSH    H          ;PRESERVE REGISTERS
0234 D5                 PUSH    D
0235 C5                 PUSH    B
0236 F5                 PUSH    PSW
0237 5F                 MOV     E,A        ;PUT CHAR IN E REGISTER
0238 0E02               MVI     C,WFUNC    ;WRITE CHARACTER FUNCTION
023A CD0500             CALL    NTRY       ;PRINT HIM
023D F1                 POP     PSW
023E C1                 POP     B
023F D1                 POP     D
0240 E1                 POP     H
0241 C9                 RET
                ;*****************************************************************
                ;
                ;     SUBROUTINE CLEAR -- CLEARS SCREEN AND HOMES CURSOR ON
                ;        A SOROC IQ-120 TERMINAL - PRESERVES REGISTERS
                ;
                ;*****************************************************************
                ;
0242 F5         CLEAR:  PUSH    PSW        ;PROTECT STATUS
0243 3E1B               MVI     A,27       ;SEND ESCAPE CODE
0245 CD3302             CALL    WCHAR
0248 3E2A               MVI     A,HOME     ;CLEAR SCREEN AND HOME CURSOR
024A CD3302             CALL    WCHAR
024D F1                 POP     PSW
024E C9                 RET
                ;*****************************************************************
                ;
                ;     SUBROUTINE CRLF -- SENDS CRLF TO CONSOLE - PRESERVES REGISTERS
                ;
                ;*****************************************************************
                ;
024F F5         CRLF:   PUSH    PSW
0250 3E0D               MVI     A,CR
0252 CD3302             CALL    WCHAR
0255 3E0A               MVI     A,LF
0257 CD3302             CALL    WCHAR
025A F1                 POP     PSW
025B C9                 RET
                ;*****************************************************************
                ;
                ;     SUBROUTINE SAVSTK -- SAVES THE OLD STACK POINTER AND SETS
                ;       A NEW STACK AT CBASE (BASE OF CONSOLE COMMAND PROCESSOR).
                ;       CBASE IS 800H BELOW FBASE (BASE OF THE DISK OPERATING SYSTEM)
                ;       FBASE MAY BE READ AT NTRY+1.
                ;
                ;*****************************************************************
                ;
025C C1         SAVSTK: POP     B          ;GET RETURN ADDRESS
025D 210000             LXI     H,00       ;CLEAR HL
0260 39                 DAD     SP         ;GET STACK POINTER
0261 220301             SHLD    OLDSTK     ;SAVE HIM
0264 2A0600             LHLD    NTRY+1     ;GET FBASE
0267 7C                 MOV     A,H
0268 D608               SUI     08H        ;SUBTRACT CBASE OFFSET
```

Listing 3 continued on page 282

Listing 3 continued:

```
026A 67                 MOV     H,A
026B F9                 SPHL             ;SET NEW STACK POINTER
026C C5                 PUSH    B        ;SET RETURN ADDRESS
026D C9                 RET
               ;**********************************************************************
               ;
               ;    SUBROUTINE GETSTK -- GETS OLD STACK POINTER AND RETURNS TO CPM
               ;
               ;**********************************************************************
               ;
026E 2A0301    GETSTK:  LHLD    OLDSTK   ;GET OLD STACK POINTER
0271 F9                 SPHL             ;PLUG IT IN
0272 C9                 RET              ;THIS WILL RETURN TO CPM
               ;**********************************************************************
               ;
               ;     MAIN PROGRAM -- PROMPTS FOR INPUT, CLEARS SCREEN AND ECHOS
               ;         THE INPUT STRING IN 32 CHARACTER LINES
               ;
               ;***********************************************************************
               ;
0273 CD5C02    BEGIN:   CALL    SAVSTK   ;SAVE OLD STACK POINTER
0276 110602             LXI     D,PROMPT
0279 CD1602             CALL    PRINT    ;PRINT PROMPT
027C CD4F02             CALL    CRLF
027F 3EFF               MVI     A,255
0281 320501             STA     STR      ;SET MAX BUFFER LENGTH
0284 3E00               MVI     A,00
0286 320601             STA     STR+1    ;ZERO CHARACTER COUNTER
0289 210501             LXI     H,STR
028C CD2402             CALL    GETBUF   ;GET A BUFFER FULL
028F CD4202             CALL    CLEAR    ;CLEAR SCREEN
0292 110C02             LXI     D,LEADER
0295 CD1602             CALL    PRINT    ;PRINT LEADER
0298 CD4F02             CALL    CRLF
029B 23                 INX     H        ;ADDRESS STR+1
029C 46                 MOV     B,M      ;NUMBER OF CHARACTERS READ IN
029D 3E20      PLIN:    MVI     A,LEN    ;LINE LENGTH
029F B8                 CMP     B
02A0 D2B402             JNC     ELIN     ;PRINT LAST LINE
02A3 4F                 MOV     C,A      ;PLACE LEN IN COUNTER
02A4 23        LINE:    INX     H        ;NEXT CHARACTER
02A5 7E                 MOV     A,M      ;GET HIM
02A6 CD3302             CALL    WCHAR    ;WRITE HIM
02A9 05                 DCR     B
02AA 0D                 DCR     C
02AB C2A402             JNZ     LINE     ;KEEP PRINTING TILL DONE
02AE CD4F02             CALL    CRLF
02B1 C39D02             JMP     PLIN     ;NEXT LINE
02B4 23        ELIN:    INX     H
02B5 7E                 MOV     A,M      ;GET CHARACTER
02B6 CD3302             CALL    WCHAR
02B9 05                 DCR     B
02BA C2B402             JNZ     ELIN     ;PRINT TILL DONE
02BD CD4F02             CALL    CRLF
02C0 CD6E02             CALL    GETSTK   ;RETURN TO CPM
02C3                    END     100H
```

Text continued from page 274:

available are P, which prints the file on the system printer, and D, which creates a copy of the input file having type .RES . The input file may reside on drive A or B, but it is assumed to be on A unless otherwise specified. If option D is selected, the output file will be on the same drive as the input file.

Now, let us discuss the use of the default FCB and buffer. When the command DSKUTIL TEST.PD is entered in response to the CP/M prompt, the system places TEST in bytes 1 thru 4 of the FCB beginning at location 005C. PD is placed in bytes 9 and 10. The string (as typed) is also placed in the default buffer at location 0080 in the following manner: byte 0 (that is, hexadecimal location 0080) contains the number of valid characters typed on the command line after the actual command and before a carriage return, in decimal. In this case, *b*TEST.PD (*b* represents a space—decimal ASCII 32) was typed—8 characters before a carriage return. Byte 0 of the buffer therefore

Text continued on page 300

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Call us today for the name of your nearest Delta distributor.

*(and save thousands later)



Listing 4: *Program using the discussed techniques to allow a user to either copy a specified file into another file or transmit its contents to the printer.*

```
                  ;************************************************************
                  ;
                  ;       CP/M DISK UTILITIES PROGRAM
                  ;       WRITTEN BY JAMES K. LARSON
                  ;
                  ;*************************************************************
                  ;
0100                      ORG     0100H
0100 C38902               JMP     BEGIN   ;SKIP TO START OF MAIN PROGRAM
                  ;************************************************************
                  ;
                  ;       EQUATES AND DATA STORAGE AREA
                  ;
                  ;************************************************************
                  ;
0005 =            NTRY    EQU     0005H   ;CPM ENTRY POINT
0002 =            WFUNC   EQU     2       ;WRITE TO CONSOLE FUNCTION
0005 =            PFUNC   EQU     5       ;LINEPRINTER FUNCTION
0009 =            PSTR    EQU     9       ;PRINT BUFFER FUNCTION
000E =            LOGF    EQU     14      ;LOGIN AND SELECT DISK
000F =            OPENF   EQU     15      ;OPEN DISK FILE
0010 =            CLOSEF  EQU     16      ;CLOSE DISK FILE
0013 =            REMVF   EQU     19      ;DELETE A DISK FILE
0014 =            READF   EQU     20      ;READ A DISK RECORD
0015 =            WRITEF  EQU     21      ;WRITE A DISK RECORD
0016 =            MAKEF   EQU     22      ;CREATE A DISK FILE
001A =            SETF    EQU     26      ;SET DMA ADDRESS FOR NEXT READ/WRITE
0080 =            TBUFF   EQU     0080H   ;DEFAULT TEXT BUFFER
005C =            TFCB    EQU     005CH   ;DEFAULT FILE CONTROL BLOCK
0080 =            RECLEN  EQU     128     ;LENGTH OF ONE DISK RECORD
000D =            CR      EQU     13      ;CARRIAGE RETURN
000A =            LF      EQU     10      ;LI NE FEED
002A =            HOME    EQU     42      ;HOME CURSOR AND CLEAR SCREEN
0103 4445         DEM:    DW      'DE'
0105 4D00000000           DB      'M',0,0,0,0
010A 5245         RES:    DW      'RE'
010C 5300000000           DB      'S',0,0,0,0
0111 5052494E54DNMSG:     DW      'PR','IN','TI','NG',' C','OM','PL','ET','E$'
0123 50524F4345DNPRC:     DW      'PR','OC','ES','SI','NG',' C','OM','PL','ET','E$'
0137 434F4D4D41ERRMSG:    DW      'CO','MM','AN','D ','OR',' F','IL','E ','ER','RO','R$'
014D 4F50454E200PERR:     DW      'OP','EN',' E','RR','OR','$ '
0159 5752495445WERR:      DW      'WR','IT','E ','ER','RO','R$'
0165              RCRDS:  DS      1       ;STORAGE FOR NUMBER OF RECORDS READ
0166              OLDSTK: DS      2       ;STORAGE FOR ORIGINAL STACK ADDRESS
0168 00           FLAG:   DB      00      ;INITIALIZE FLAG BITS STORAGE
0169              TFCB1:  DS      33      ;SECOND FILE CONTROL BLOCK
                  ;*************************************************************
                  ;    SUBROUTINE PRINT -- PRINTS A STRING ENDING IN $
                  ;       PLACE STRING BUFFER STARTING ADDRESS IN DE REGISTER
                  ;       PRESERVES REGISTER CONTENTS
                  ;
                  ;***************************************************************
                  ;
018A E5           PRINT:  PUSH    H       ;PRESERVE REGISTERS
018B D5                   PUSH    D
018C C5                   PUSH    B
018D F5                   PUSH    PSW
018E 0E09                 MVI     C,PSTR  ;FUNCTION IN C REGISTER
0190 CD0500               CALL    NTRY    ;DO IT
0193 F1                   POP     PSW     ;RESTORE REGISTERS
0194 C1                   POP     B
0195 D1                   POP     D
0196 E1                   POP     H
017 C9                   RET
                  ;****************************************************************
                  ;
                  ;    SUBROUTINE WCHAR -- WRITES A SINGLE CHARACTER TO THE CONSOLE
                  ;       CHARACTER IN THE A REGISTER - PRESERVES REGISTERS
```

Listing 4 continued on page 286

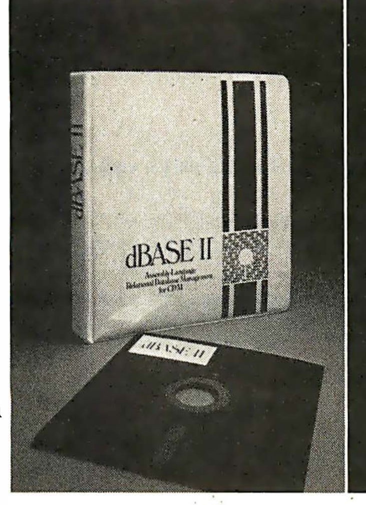
dBASE™ II vs. the Bilge Pumps.

by Hal Pawluk

We all know that bilge pumps suck.

And by now, we've found out—the hard way—that a lot of software seems to work the same way.

So I got pretty excited when I ran across **dBASE II**, an assembly-language relational Database Management System for CP/M. It works! And even a rank beginner like myself got it up and running the first time I sat down with it.



If you're looking for software to deal with your data, too, here are some tips that will help:

Tip #1: Database Management vs. File Handling:

Any list or collection of data is, loosely, a data base, but most of those "data base management" articles in the buzzbooks are really about file handling programs for specific applications. A real Database Management System gives you data and program independence (no reprogramming when data changes), eliminates data duplication and makes it easy to turn data into information.

Tip #2: Assembly Language vs. BASIC:

This one's easy: if you're setting up a DBMS, you're going to be doing a lot of sorting, and Basic sorts are s-l-o-w. Run a benchmark on a Basic system like S*-IV against a relational DBMS like **dBASE II** and you'll see what I mean. (But watch it: I've also seen one extremely slow assembly-language file management system.)

Tip #3: Relational vs. Hierarchal & Network DBMS.

CODASYL-like hierarchal and network systems, around since the 1960's, are being phased out on the big machines so why get stuck with an old-fashioned system for your micro? A relational DBMS like **dBASE II** eliminates the predefined sets, pointers and complex data structures of a CODASYL-type DBMS. And you don't need to be a programmer to use it.

dBASE II vs. everything else.

dBASE II really impressed me.

Written in assembly language (with no need for a host language), it handles up to 65,000 records (up to 32 fields and 1000 bytes each), stores numeric data as packed strings so there are no round-off errors, has a super-fast multiple-key sort, and supports ISAM based on B* trees.

You can use it interactively with English-like commands (DISPLAY 10 PRODUCTS), or program it (so when you've set up the formats, your secretary can do the work). Its report generator and user-definable full screen operations mean that you can even use your existing forms.

And if all this makes your mouth water, but you've already got all your data on a disk, that's okay: **dBASE II** reads your ASCII files and adds the data to its own database.

Right now, I'm using **dBASE II** with my word processor for budgeting, scheduling and preparing reports for my clients.

Next come job costing, time billing and accounting.

An Unheard-of Money-Back Guarantee.

dBASE II is the first software I've seen with a full money-back guarantee.

To check it out, just send $700 (plus tax in California) to Ashton-Tate, 3600 Wilshire Blvd., Suite 1510, Los Angeles, CA 90010. (213) 666-4409. Test **dBASE II** doing your jobs on your computer for 30 days. If, for some strange reason, you don't want to keep it, send it back and they'll refund your money.

No questions asked.

They know you don't need your bilge pumped.

Ashton-Tate

Circle 28 on inquiry card.

```
                ;
                ;*****************************************************************
                ;
0198 E5         WCHAR:  PUSH    H
0199 D5                 PUSH    D
019A C5                 PUSH    B
019B F5                 PUSH    PSW
019C 5F                 MOV     E,A        ;CHARACTER IN E REGISTER
019D 0E02               MVI     C,WFUNC
019F CD0500             CALL    NTRY
01A2 F1                 POP     PSW
01A3 C1                 POP     B
01A4 D1                 POP     D
01A5 E1                 POP     H
01A6 C9                 RET
                ;*****************************************************************
                ;
                ;     SUBROUTINE PCHAR -- PRINTS A SINGLE CHARACTER ON THE PRINTER
                ;        CHARACTER IN THE A REGISTER - PRESERVES REGISTERS
                ;
                ;*****************************************************************
                ;
01A7 E5         PCHAR:  PUSH    H
01A8 D5                 PUSH    D
01A9 C5                 PUSH    B
01AA F5                 PUSH    PSW
01AB 5F                 MOV     E,A
01AC 0E05               MVI     C,PFUNC
01AE CD0500             CALL    NTRY
01B1 F1                 POP     PSW
01B2 C1                 POP     B
01B3 D1                 POP     D
01B4 E1                 POP     H
01B5 C9                 RET
                ;*****************************************************************
                ;
                ;     SUBROUTINE CLEAR -- CLEARS SCREEN AND HOMES CURSOR ON
                ;        A SOROC IQ-120 TERMINAL -- PRESERVES REGISTERS
                ;
                ;*****************************************************************
                ;
01B6 F5         CLEAR:  PUSH    PSW        ;PROTECT STATUS
01B7 3E1B               MVI     A,27       ;SEND ESCAPE CODE
01B9 CD9801             CALL    WCHAR
01BC 3E2A               MVI     A,HOME
01BE CD9801             CALL    WCHAR
01C1 F1                 POP     PSW
01C2 C9                 RET
                ;*****************************************************************
                ;
                ;    SUBROUTINE CRLF -- SENDS CRLF TO CONSOLE
                ;
                ;*****************************************************************
                ;
01C3 F5         CRLF:   PUSH    PSW
01C4 3E0D               MVI     A,CR
01C6 CD9801             CALL    WCHAR
01C9 3E0A               MVI     A,LF
01CB CD9801             CALL    WCHAR
01CE F1                 POP     PSW
01CF C9                 RET
                ;*****************************************************************
                ;
                ;     SUBROUTINE SAVSTK -- SAVES THE OLD STACK POINTER AND SETS
                ;        A NEW STACK AT CBASE (BASE OF THE CONSOLE COMMAND PROCESSOR).
                ;        CBASE IS 800H BELOW FBASE (BASE OF THE DISK OPERATING SYSTEM).
                ;        FBASE MAY BE READ AT NTRY+1.
                ;
                ;*****************************************************************
```

Listing 4 continued on page 288

Listing 4 continued:

```
                    ;
01D0 C1             SAVSTK: POP     B           ;GET RETURN ADDRESS
01D1 210000                 LXI     H,00        ;CLEAR HL
01D4 39                     DAD     SP          ;GET STACK POINTER
01D5 226601                 SHLD    OLDSTK      ;SAVE HIM
01D8 2A0600                 LHLD    NTRY+1      ;GET FBASE
01DB 7C                     MOV     A,H
01DC D608                   SUI     08H         ;SUBTRACT CBASE OFFSET
01DE 67                     MOV     H,A
01DF F9                     SPHL                ;SET NEW STACK POINTER
01E0 C5                     PUSH    B           ;SET RETURN ADDRESS
01E1 C9                     RET
                    ;*******************************************************************
                    ;
                    ;     SUBROUTINE GETSTK -- GETS OLD STACK POINTER AND RETURNS TO CPM
                    ;
                    ;*******************************************************************
                    ;
01E2 2A6601         GETSTK: LHLD    OLDSTK      ;GET OLD STACK POINTER
01E5 F9                     SPHL                ;PLUG HIM IN
01E6 C9                     RET                 ;THIS WILL RETURN TO CPM
                    ;*******************************************************************
                    ;
                    ;     SUBROUTINE PRT -- PRINTS THE NUMBER OF CHARACTERS IN THE B REG
                    ;        ON THE LINE PRINTER. ADDRESS OF FIRST CHARACTER TO PRINT
                    ;        IS IN HL.
                    ;
                    ;*******************************************************************
                    ;
01E7 7E             PRT:    MOV     A,M         ;GET CHAR
01E8 CDA701                 CALL    PCHAR       ;PRINT HIM
01EB 23                     INX     H           ;NEXT, PLEASE
01EC 05                     DCR     B           ;DONE?
01ED C2E701                 JNZ     PRT         ;NOPE, KEEP PRINTING
01F0 C9                     RET                 ;DONE, GO HOME
                    ;*******************************************************************
                    ;
                    ;     SUBROUTINE MOVCHR -- MOVES CHARACTERS BEGINNING AT LOCATION
                    ;        IN HL TO LOCATION BEGINNING IN DE FOR A COUNT IN REG C.
                    ;
                    ;*******************************************************************
                    ;
01F1 7E             MOVCHR: MOV     A,M
01F2 12                     STAX    D
01F3 23                     INX     H
01F4 13                     INX     D
01F5 0D                     DCR     C
01F6 C2F101                 JNZ     MOVCHR      ;GO TILL DONE
01F9 C9                     RET
                    ;*******************************************************************
                    ;
                    ;     SUBROUTINE LOGDSK -- LOGS IN A DISK AS ACTIVE FOR I/O. REG E
                    ;        CONTAINS 0 FOR DRIVE A AND 1 FOR DRIVE B.
                    ;
                    ;*******************************************************************
                    ;
01FA E5             LOGDSK: PUSH    H
01FB D5                     PUSH    D           ;PRESERVE
01FC C5                     PUSH    B
01FD F5                     PUSH    PSW
01FE 0E0E                   MVI     C,LOGF
0200 CD0500                 CALL    NTRY
0203 F1                     POP     PSW
0204 C1                     POP     B           ;RESTORE
0205 D1                     POP     D
0206 E1                     POP     H
0207 C9                     RET
                    ;*******************************************************************
                    ;
```

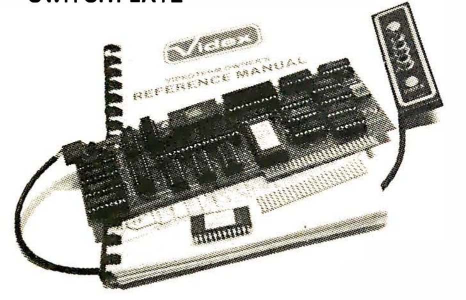
Listing 4 continued on page 290

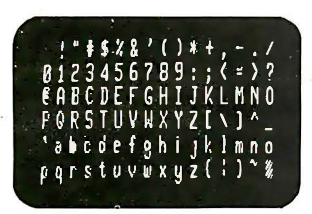
The Text Solution for APPLE II®

Now APPLE II® Owners Can Solve Text Problems With VIDEOTERM 80 Column by 24 Line Video Display Utilizing 7 X 9 Dot Character Matrix

Perhaps the most annoying shortcoming of the Apple II® is its limitation of displaying only 40 columns by 24 lines of text, all in uppercase. At last, Apple II® owners have a reliable, trouble-free answer to their text display problem. VIDEOTERM generates a full 80 columns by 24 lines of text, in upper and lower case. Twice the number of characters as the standard Apple II® display. And by utilizing a 7 by 9 character matrix, lower case letters have true descenders. But this is only the start.

VIDEOTERM, MANUAL, SWITCHPLATE





7X12 MATRIX
18X80 OPTIONAL

7X9 MATRIX
24X80 STANDARD

VIDEOTERM

BASICs VIDEOTERM lists BASIC programs, both Integer and Applesoft, using the entire 80 columns. Without splitting keywords. Full editing capabilities are offered using the ESCape key sequences for cursor movement. With provision for stop/start text scrolling utilizing the standard Control-S entry. And simultaneous on-screen display of text being printed.

Pascal Installation of VIDEOTERM in slot 3 provides Pascal immediate control of the display since Pascal recognizes the board as a standard video display terminal and treats it as such. No changes are needed to Pascal's MISC.INFO or GOTOXY files, although customization directions are provided. All cursor control characters are identical to standard Pascal defaults.

Other Boards The new Microsoft Softcard* is supported. So is the popular D. C. Hayes Micromodem II*, utilizing customized PROM firmware available from VIDEX. The powerful EasyWriter* Professional Word Processing System and other word processors are now compatible with VIDEOTERM. Or use the Mountain Hardware ROMWriter* (or other PROM programmer) to generate your own custom character sets. Naturally, VIDEOTERM conforms to all Apple OEM guidelines, assurance that you will have no conflicts with current or future Apple II* expansion boards.

Advanced Hardware Design VIDEOTERM's on-board asynchronous crystal clock ensures flicker-free character display. Only the size of the Pascal Language card, VIDEOTERM utilizes CMOS and low power consumption ICs, ensuring cool, reliable operation. All ICs are fully socketed for easy maintenance. Add to that 2K of on-board RAM, 50 or 60 Hz operation, and provision of power and input connectors for a light pen. Problems are designed out, not in.

Available Options The entire display may be altered to inverse video, displaying black characters on a white field. PROMs containing alternate character sets and graphic symbols are available from Videx. A switchplate option allows you to use the same video monitor for either the VIDEOTERM or the standard Apple II* display, instantly changing displays by flipping a single toggle switch. The switchplate assembly inserts into one of the rear cut-outs in the Apple II* case so that the toggle switch is readily accessible. And the Videx KEYBOARD ENHANCER can be installed, allowing upper and lower case character entry directly from your Apple II* keyboard.

Firmware 1K of on-board ROM firmware controls all operation of the VIDEOTERM. No machine language patches are needed for normal VIDEOTERM use.

Firmware Version 2.0

Characters Options	7 x 9 matrix 7 x 12 matrix option; Alternate user definable character set option; Inverse video option.	Display	24 x 80 (full descenders) 18 x 80 (7 x 12 matrix with full descenders)

Want to know more? Contact your local Apple dealer today for a demonstration. VIDEOTERM is available through your local dealer or direct from Videx in Corvallis, Oregon. Or send for the VIDEOTERM Owners Reference Manual and deduct the amount if you decide to purchase. Upgrade your Apple II* to full terminal capabilities for half the cost of a terminal. VIDEOTERM. At last.

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ROMWriter* is a trademark of Mountain Hardware Inc.
Micromodem II* is a trademark of D. C. Hayes Associates Inc.
Softcard* is a trademark of Microsoft
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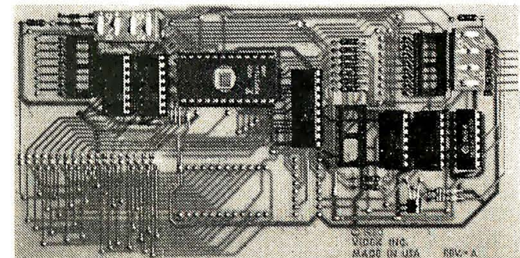
PRICE:
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Videx has the perfect companion for your word processor software: the **KEYBOARD AND DISPLAY ENHANCER**. Install the enhancer in your APPLE II and be typing in lower case just like a typewriter. If you want an upper case character, use the SHIFT key or the CTRL key for shift lock. Not only that, but you see upper and lower case on the screen as you type. Perfectly compatible with Apple Writer and other word processors like, for example, Super-Text.

If you want to program in BASIC, just put it back into the alpha lock mode; and you have the original keyboard back with a few improvements. Now you can enter those elusive 9 characters directly from the keyboard, or require the Control key to be pressed with the RESET to prevent accidental resets.

KEYBOARD AND DISPLAY ENHANCER is recommended for use with all revisions of the APPLE II. It includes 6 ICs, and EPROM and dip-switches mounted on a PC board, and a jumper cable. Easy installation, meaning no soldering or cutting traces. Alternate default modes are dip-switch selectable. You can even remap the keyboard, selecting an alternate character set, for custom applications.







VIDEX
897 N.W. Grant Avenue
Corvallis, Oregon 97330
Phone (503) 758-0521

Listing 4 continued:

```
                        ;     SUBROUTINE OPEN -- OPENS FILE WHOSE FCB ADDRESS IS IN DE.
                        ;        RETURNS 255 IN REG A IF NO SUCH FILE.
                        ;
                        ;************************************************************************
                        ;
0208 E5                 OPEN:   PUSH    H       ;PRESERVE
0209 D5                         PUSH    D
020A C5                         PUSH    B
020B 0E0F                       MVI     C,OPENF
020D CD0500                     CALL    NTRY
0210 C1                         POP     B
0211 D1                         POP     D
0212 E1                         POP     H
0213 C9                         RET
                        ;************************************************************************
                        ;
                        ;     SUBROUTINE CLOSE -- CLOSES FILE WHOSE FCB ADDRESS IS IN DE.
                        ;        RETURNS 255 IN A IF NO SUCH FILE.
                        ;
                        ;************************************************************************
                        ;
0214 E5                 CLOSE:  PUSH    H
0215 D5                         PUSH    D
0216 C5                         PUSH    B
0217 0E10                       MVI     C,CLOSEF
0219 CD0500                     CALL    NTRY
021C C1                         POP     B
021D D1                         POP     D
021E E1                         POP     H
021F C9                         RET
                        ;************************************************************************
                        ;
                        ;     SUBROUTINE DELETE -- DELETES THE FILE WHOSE FCB IS IN DE.
                        ;
                        ;************************************************************************
                        ;
0220 E5                 DELETE: PUSH    H
0221 D5                         PUSH    D
0222 C5                         PUSH    B
0223 F5                         PUSH    PSW
0224 0E13                       MVI     C,REMVF
0226 CD0500                     CALL    NTRY
0229 F1                         POP     PSW
022A C1                         POP     B
022B D1                         POP     D
022C E1                         POP     H
022D C9                         RET
                        ;************************************************************************
                        ;
                        ;     SUBROUTINE CREATE -- CREATES THE FILE WHOSE FILENAME AND TYPE
                        ;        ARE IN THE FCB ADDRESSED BY DE. RETURNS 255 IN A IF NO
                        ;        DIRECTORY SPACE.
                        ;
                        ;************************************************************************
                        ;
022E E5                 CREATE: PUSH    H
022F D5                         PUSH    D
0230 C5                         PUSH    B
0231 0E16                       MVI     C,MAKEF
0233 CD0500                     CALL    NTRY
0236 C1                         POP     B
0237 D1                         POP     D
0238 E1                         POP     H
0239 C9                         RET
                        ;************************************:***********************************
                        ;
                        ;     SUBROUTINE SETDMA -- SETS THE DMA ADDRESS FOR THE NEXT DISK I/O
                        ;        TO THAT IN HL.  INCREMENTS HL BY 128 (READY FOR NEXT TIME).
                        ;
```

Listing 4 continued on page 292



APPLE ACCESSORIES

LOBO Disk II/Controller	$499.
LOBO Disk II	419.
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D-CAT, *direct*	169.
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HAYES Micromodem, S100	349.

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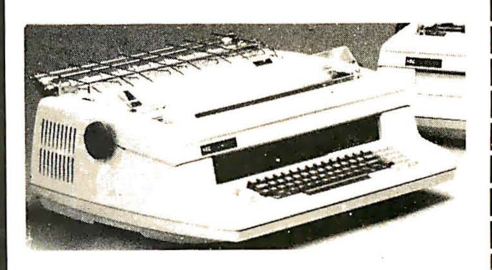


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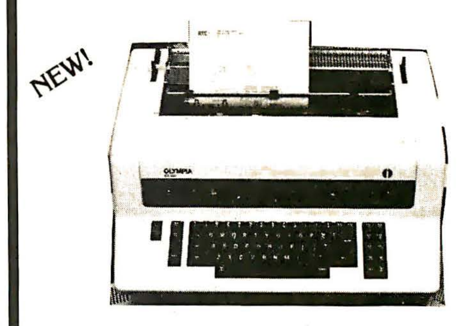
Apple II I/O Card	$110.00
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Circle 280 on inquiry card.

Listing 4 continued:

```
                 ;**********************************************************************
                 ;
023A F5          SETDMA: PUSH    PSW
023B C5                  PUSH    B
023C D5                  PUSH    D
023D E5                  PUSH    H
023E EB                  XCHG                    ;ADDRESS IN DE
023F 0E1A                MVI     C,SETF
0241 CD0500              CALL    NTRY
0244 E1                  POP     H               ;MODIFY THIS GUY
0245 018000              LXI     B,128
0248 09                  DAD     B               ;ADDRESS+128
0249 D1                  POP     D
024A C1                  POP     B               ;RESTORE
024B F1                  POP     PSW
024C C9                  RET
                 ;**********************************************************************
                 ;
                 ;     SUBROUTINE RDREC -- READS ONE RECORD FROM FILE WHOSE FCB IS IN
                 ;         DE TO THE CURRENT DMA ADDRESS. RETURNS A 1 OR 2 IN REG A
                 ;         IF EOF IS ENCOUNTERED. A ZERO IN REG A MEANS SUCCESSFUL READ.
                 ;
                 ;**********************************************************************
                 ;
024D E5          RDREC:  PUSH    H
024E D5                  PUSH    D
024F C5                  PUSH    B
0250 0E14                MVI     C,READF
0252 CD0500              CALL    NTRY
0255 C1                  POP     B
0256 D1                  POP     D
0257 E1                  POP     H
0258 C9                  RET
                 ;**********************************************************************
                 ;
                 ;     SUBROUTINE WRREC -- WRITES ONE RECORD TO FILE WHOSE FCB IS IN
                 ;         DE FROM THE CURRENT DMA ADDRESS. RETURNS 0 IF A SUCCESSFUL
                 ;         WRITE.
                 ;
                 ;**********************************************************************
                 ;
0259 E5          WRREC:  PUSH    H
025A D5                  PUSH    D
025B C5                  PUSH    B
025C 0E15                MVI     C,WRITEF
025E CD0500              CALL    NTRY
0261 C1                  POP     B
0262 D1                  POP     D
0263 E1                  POP     H
0264 C9                  RET
                 ;**********************************************************************
                 ;
                 ;     SUBROUTINE RDDSK -- READS FILE WHOSE FCB ADDRESS IS IN DE TO
                 ;         MEMORY BEGINNING AT ADDRESS IN HL. ASSUMES FILE WILL FIT INTO
                 ;         MEMORY. ENTIRE FILE IS READ IN.
                 ;
                 ;**********************************************************************
                 ;
0265 CD3A02      RDDSK:  CALL    SETDMA
0268 CD4D02              CALL    RDREC
026B A7                  ANA     A               ;SET STATUS FLAGS - REG A WILL BE NON-ZERO
                                                 ;    IF AN EOF WAS ENCOUNTERED
026C CA6502              JZ      RDDSK           ;READ TILL EOF
026F C9                  RET
                 ;**********************************************************************
                 ;
                 ;     SUBROUTINE WRDSK -- WRITES TO DISK FROM MEMORY BEGINNING AT
                 ;       ADDRESS IN HL. WRITES FILE WHOSE FCB IS IN DE. WRITES NUMBER
                 ;         OF RECORDS IN REG B. ANY ERRORS RETURNED FROM WRREC ARE
                 ;         REPORTED AND THE WRITE IS ABORTED.
```

Listing 4 continued on page 294

Listing 4 continued:

```
                ;
                ;*********************************************************************
                ;
0270 CD3A02     WRDSK:  CALL    SETDMA
0273 CD5902             CALL    WRREC
0276 A7                 ANA     A       ;SET STATUS FLAGS - REG A WILL BE NON-ZERO
                                        ;    IF AN ERROR OCCURRED
0277 C27F02             JNZ     WRER    ;REPORT ERROR
027A 05                 DCR     B       ;THUMP RECORD COUNTER
027B C27002             JNZ     WRDSK   ;WRITE EM ALL
027E C9                 RET
027F 115901     WRER:   LXI     D,WERR  ;PRINT ERROR MESSAGE
0282 CD8A01             CALL    PRINT
0285 CDC301             CALL    CRLF
0288 C9                 RET
                ;*********************************************************************
                ;
                ;   MAIN PROGRAM -- READS A DISK DRIVE, FILE NAME, AND OPTIONS FROM
                ;       THE DEFAULT BUFFER . OPTIONS ALLOW THE NAMED FILE TO BE
                ;       PRINTED OR REWRITTEN TO A NEW FILE. ASSUMES FILE TYPE .DEM
                ;       FOR INPUT FILE AND ASSIGNS TYPE .RES TO OUTPUT FILE.
                ;
                ;*********************************************************************
                ;
0289 CDD001     BEGIN:  CALL    SAVSTK  ;SAVE OLD STACK POINTER
028C CDB601             CALL    CLEAR
028F 218000             LXI     H,TBUFF ;COMMAND LINE IS HERE
0292 3E00               MVI     A,0
0294 BE                 CMP     M
0295 CAA303             JZ      ERR     ;ERROR IF NO VALID CHARACTERS
0298 46                 MOV     B,M     ;GET NUMBER OF VALID CHARACTERS
0299 3E3A               MVI     A,':'   ;DISK SPECIFIED?
029B 23                 INX     H
029C 23                 INX     H
029D 23                 INX     H       ;COLON IS HERE IF A LABEL IS SPECIFIED
029E BE                 CMP     M
029F CAA802             JZ      LDSK    ;LOG PROPER DISK
02A2 2B                 DCX     H
02A3 2B                 DCX     H
02A4 05                 DCR     B       ;ASSUME FIRST CHARACTER BLANK
02A5 C3BF02             JMP     TARG    ;SKIP IF NOT NEEDED
02A8 05         LDSK:   DCR     B       ;THUMP COUNTER
02A9 05                 DCR     B
02AA 05                 DCR     B
02AB 3E42               MVI     A,'B'   ;DRIVE B?
02AD 2B                 DCX     H       ;BACK UP ONE
02AE BE                 CMP     M
02AF CAB602             JZ      DRB     ;DRIVE B IT IS
02B2 23                 INX     H       ;ASSUME DRIVE A
02B3 C3BF02             JMP     TARG
02B6 3A6801     DRB:    LDA     FLAG    ;FLAG DRIVE B
02B9 F604               ORI     00000100B
02BB 326801             STA     FLAG
02BE 23                 INX     H
02BF 3E2E       TARG:   MVI     A,'.'   ;TARGET IS END OF FILE NAME
02C1 23         NCHAR:  INX     H       ;NEXT CHAR
02C2 05                 DCR     B       ;THUMP COUNTER
02C3 CAA303             JZ      ERR     ;ERROR IF NO COMMANDS
02C6 BE                 CMP     M
02C7 C2C102             JNZ     NCHAR   ;KEEP LOOKING
02CA 23                 INX     H
02CB 3E50       INSTR:  MVI     A,'P'   ;PRINT HIM?
02CD BE                 CMP     M
02CE C2DC02             JNZ     DTST
02D1 3A6801             LDA     FLAG    ;SET PRINT FLAG
02D4 F601               ORI     00000001B
02D6 326801             STA     FLAG
02D9 C3EA02             JMP     NXTINS
02DC 3E44       DTST:   MVI     A,'D'   ;CREATE NEW DISK FILE?
02DE BE                 CMP     M
```

Listing 4 continued on page 296

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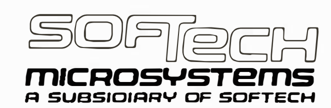
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Listing 4 continued:

```
02DF C2EA02           JNZ     NXTINS   ;INVALID INSTRUCTIONS ARE SKIPPED
02E2 3A6801           LDA     FLAG     ;SET FILE FLAG
02E5 F602             ORI     00000010B
02E7 326801           STA     FLAG
02EA 23      NXTINS:  INX     H
02EB 05               DCR     B
02EC C2CB02           JNZ     INSTR    ;KEEP READING INSTRUCTIONS
                                       ;
                                       ;LOG PROPER DRIVE
                                       ;
02EF 1E00             MVI     E,00     ;SET DEFAULT DRIVE A
02F1 3A6801           LDA     FLAG
02F4 E604             ANI     00000100B        ;WHICH DRIVE?
02F6 CAFB02           JZ      LOG      ;LOG DRIVE A
02F9 1E01             MVI     E,01     ;LOG DRIVE B
02FB CDFA01  LOG:     CALL    LOGDSK
                                       ;
                                       ;SET FILE TYPE .DEM
                                       ;
02FE 210301           LXI     H,DEM
0301 116500           LXI     D,TFCB+9
0304 0E07             MVI     C,7      ;MOVE 7 CHARACTERS -- .DEM AND ZEROS
0306 CDF101           CALL    MOVCHR
0309 AF               XRA     A        ;CLEAR A
030A 327C00           STA     TFCB+32  ;ZERO NEXT RECORD
                                       ;
                                       ;READ IN FILE
                                       ;
030D 115C00           LXI     D,TFCB
0310 CD0802           CALL    OPEN
0313 3C               INR     A        ;ERROR TEST - A CONTAINS 255 IF ERROR
0314 C22303           JNZ     RDSK     ;OK- GO ON
0317 114D01           LXI     D,OPERR  ;PRINT OPEN ERROR
031A CD8A01           CALL    PRINT
031D CDC301           CALL    CRLF
0320 C39703           JMP     DONE
0323 21AF03  RDSK:    LXI     H,FINIS  ;LOCATION OF FIRST OPEN MEMORY LOCATION
                                       ;DE ALREADY CONTAINS THE FCB ADDRESS
0326 CD6502           CALL    RDDSK    ;READ HIM IN
0329 3A6B00           LDA     TFCB+15  ;NUMBER OF RECORDS READ IN
032C 326501           STA     RCRDS
032F CD1402           CALL    CLOSE    ;TFCB IS STILL IN DE
                                       ;
                                       ;PRINT ON LINE PRINTER IF FLAG SET
                                       ;
0332 3A6801           LDA     FLAG
0335 E601             ANI     00000001B
0337 CA5803           JZ      FILE     ;TEST FOR FILE FLAG
033A 3A6501           LDA     RCRDS    ;NUMBER OF RECORDS TO PRINT
033D 4F               MOV     C,A
033E 0D               DCR     C
033F 21AF03           LXI     H,FINIS  ;FIRST CHARACTER
0342 118000           LXI     D,128    ;INCREMENT
0345 0680    PRTMOR:  MVI     B,RECLEN         ;SET RECORD LENGTH
0347 CDE701           CALL    PRT      ;PRINT ONE RECORD
034A 19               DAD     D        ;INCREMENT CHAR COUNT
034B 0D               DCR     C
034C C24503           JNZ     PRTMOR   ;PRINT MORE
034F 111101           LXI     D,DNMSG  ;PRINT COMPLETION MESSAGE
0352 CD8A01           CALL    PRINT
0355 CDC301           CALL    CRLF
                                       ;
                                       ;IF FILE FLAG SET, CREATE NEW FILE
                                       ;
0358 3A6801  FILE:    LDA     FLAG
035B E602             ANI     00000010B
035D CA9703           JZ      DONE
                                       ;
                                       ;IF FILE .RES EXISTS, DELETE IT - THEN CREATE IT
                                       ;
```

Listing 4 continued on page 298

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Listing 4 continued:

```
0360 215C00              LXI    H,TFCB   ;MOVE FILE NAME
0363 116901              LXI    D,TFCB1
0366 0E09                MVI    C,9
0368 CDF101              CALL   MOVCHR
036B 210A01              LXI    H,RES    ;FILE TYPE .RES
036E 117201              LXI    D,TFCB1+9
0371 0E07                MVI    C,7      ;SET TYPE AND ZERO REST OF FCB
0373 CDF101              CALL   MOVCHR
0376 AF                  XRA    A        ;CLEAR A
0377 328901              STA    TFCB1+32 ;ZERO NEXT RECORD
037A 116901              LXI    D,TFCB1  ;DESTINATION FILE
037D CD0802              CALL   OPEN
0380 3C                  INR    A        ;DOES FILE EXIST?
0381 C28703              JNZ    MAKUM    ;NOPE, LETS CREATE
0384 CD2002              CALL   DELETE   ;YUP, LETS DELETE
0387 CD2E02     MAKUM:   CALL   CREATE   ;FCB IS STILL IN DE
                                         ;FILE NOW EXISTS - WRITE TO HIM
038A 3A6501              LDA    RCRDS    ;NUMBER OF RECORDS TO WRITE
038D 47                  MOV    B,A
038E 21AF03              LXI    H,FINIS  ;LOCATION OF FIRST CHARACTER TO WRITE
0391 CD7002              CALL   WRDSK    ;WRITE HIM
0394 CD1402              CALL   CLOSE
0397 112301     DONE:    LXI    D,DNPRC  ;PRINT COMPLETION MESSAGE
039A CD8A01              CALL   PRINT
039D CDC301              CALL   CRLF
03A0 CDE201              CALL   GETSTK   ;RETURN TO CPM
03A3 213701     ERR:     LXI    H,ERRMSG
03A6 CD8A01              CALL   PRINT
03A9 CDC301              CALL   CRLF
03AC C39703              JMP    DONE
03AF            FINIS:   END    100H
```

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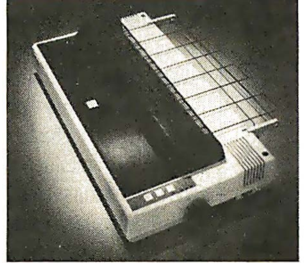
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Text continued from page 282:

contains 8. The next 8 characters are the exact line as typed: *b*TEST.PD. This buffer may now be scanned for valid commands by the user program; listing 4 illustrates a method of doing this.

If a second file name and file type had been specified, they would have been placed in the second 16 bits of the default FCB and written into the buffer. Any data placed in the buffer or FCB in this manner must be read by the user program before doing any disk access, or it will be lost. The first file name/file type may be left in the default FCB, but the second one must be moved elsewhere before accessing any file utilities (including directory utilities). In listing 4, valid commands are searched for, then the file type .DEM is placed in the FCB and bytes 12 thru 15 and 32 are zeroed. The file may now be opened and accessed.

Listing 4 illustrates one other important point about the FCB: the method of creating additional FCBs. TFCB1 is thirty-three reserved locations that serve as a second FCB in the same manner as the default FCB. The file name is moved into bytes 1 thru 8, the file type .RES is placed in bytes 9 thru 11, and the remaining bytes are defined in a similar manner to the default FCB. Using this method, additional FCBs may be created as needed. The address of the FCB of the file to be operated on is sent in the call to the CP/M entry point in register pair DE.

One other important consideration in actually reading and writing to a disk file is the need to set the DMA (direct memory access) address. This is the beginning memory address for the next disk access. The 128-byte record read from (or written to) the disk is placed into (or taken from) memory beginning at this location. When the disk system is initialized, using functions 13 or 14, the DMA address is set to hexadecimal 0080, the default buffer. It is possible to read one record to this buffer and then transfer the data to where it is needed; however, there is a simpler way illustrated in listing 4. Set the DMA address to the desired destination address and read a record. Put this function in a loop to read an entire file. Files may also be written in a similar manner (see listing 4).

Possibilities

In the course of experimenting with CP/M—trying to discover the hidden meaning in commands not thoroughly explained in the manuals—I discovered a few interesting features. These features often have no explanation in the manual. First, the directory of any disk can be read by placing ???????? and ??? in the file-name and file-type bytes of an FCB, then doing a SEARCH and SEARCH NEXT (functions 17 and 18). These two functions write directory information into the default buffer at hexadecimal location 0080, where it may be accessed for printout.

The OPEN function first finds a file name/file type match, then copies the disk map into the FCB. If a disk map is supplied with an extent, record count, and next record, the READ or WRITE functions will work without first using OPEN. The CLOSE statement merely matches the file name/file type and writes the FCB disk map to the directory.

These last two items should suggest some interesting but dangerous possibilities. The fact that CP/M marks a file as deleted by placing the hexadecimal character E5 in the entry-type field suggests a possible way to protect a file simply by making it disappear. The FCB still appears in the directory, but no longer matches any search string. This one needs more experimentation, since writing to a disk with files erased in this manner can result in destroying files only meant to be hidden.

Conclusion

This article has presented the use of the CP/M-utility routines, typical calling sequences, applications subroutines, sent and returned values, and examples of their uses. Although written specifically for CP/M, it illustrates the general method of using utility routines supplied with an operating system. In addition, some possibilities for further experimentation with CP/M have been suggested. It is not meant to supplant the Digital Research manuals, but to supplement and clarify a portion of them. You should refer to the manuals for additional information. ■

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Build a Super Simple Floppy-Disk Interface

Part 2: Software

James Nicholson and Roger Camp
1046 Gaskill
Ames IA 50010

The first part of this article presented basic floppy-disk technology and a description of a simple controller design with its circuit details. This controller provides a great deal of function and flexibility when combined with some simple software.

Software

The software shown in listing 1 provides disk-formatting, reading, writing, and error-recovery functions. The software can be reassembled to allow relocation of program or page zero variables. Various entry points are shown in table 4.

Before using the FD1771 to read and write data within the sectors on the floppy disk, the disk must be formatted to conform to a certain structure. A program (entry point FORMAT) is supplied that formats all 77 tracks of a standard 8-inch disk in a standard IBM-compatible 128-bytes-per-sector arrangement (each track contains 26 sectors).

The program, when called, initializes all 6520 and 1771 electronic interfaces before writing the standard track. The initialization process guarantees that the head is positioned over the outermost track. Each track is written from a standard pattern contained in programmable memory. A 40 ms delay is generated following a step-in function to move the head to the next track. This guarantees the proper head-settling time required by the floppy-disk drive. This process continues until all tracks have been formatted.

Sector sizes other than 128 bytes can be selected by initializing the 1771 differently. (A sector size other than 128 can lead to incompatibilities with *other* floppy-disk systems.) For sector lengths greater than 128, the FORMAT program must be rewritten to use an entire track image in memory. This is required because of an indexing limit of 256 using the 6502 microprocessor. Our system, using sixteen 256-byte sectors per track, has proven to be a convenient alternative.

When a disk is properly formatted, the basic I/O (input/output) program (entry point FDENT) can be used. If the system has just been turned on, entry point FDENT should be called first to initialize all interface and drive electronics. To perform disk operations, certain variables must be set up before calling FDENT. They include the desired *command*, *track number*, and *sector number*, as well as the address in memory used for data transfer (see table 5).

The program begins by analyzing the command to determine which segment of the program must be used in response. There are three basic command types:

- head movement
- read/write sectors
- read/write raw tracks

In the case of read/write commands, the program ascertains if the head is positioned properly and, if necessary, provides the seek command to move it.

Following execution of the command by the 1771, completion

Name	Purpose
FORMAT	Write proper track format on all 77 tracks
FDINT	Initialize 6520 and 1771 interface
FDENT	Perform basic floppy-disk operations using established variables
FDIO	Uses FDENT, followed by error checking and retry

Table 4: *Entry points for various floppy-disk controller operations.*

Name	Length in Bytes	Purpose
DVCODE	1	Device-selection byte 00 = DVC 0, 80 = DVC 1
ERRCDE	1	FF = Error, 00 = Normal Set by FDIO
COMMAND	1	1771 Command byte
STATUS	1	1771 Completion status
TRACK	1	Desired track value
SECTOR	1	Desired sector value
FDBUF	2	Address of data buffer

Table 5: *Variables used to perform floppy-disk operations. All values are listed in hexadecimal.*

The numbering of all nontext material is continued from part 1 of this article.

BYTEWRITER-1

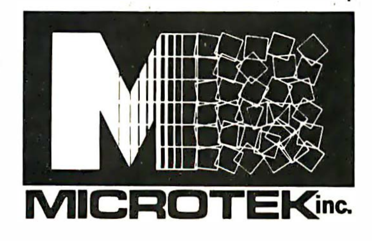
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analysis is performed to read back and store the status, track number, and sector number from the 1771. The status can then be examined by the user program to determine if the operation was successful. No registers are saved by any of the routines previously discussed.

Although the hardware design has proven to be very reliable, an error occasionally occurs. Since it would be a great burden for each application to concern itself with error recovery, another program has been provided. Using entry point FDIO, a user program can add the error-recovery function to that provided by FDENT.

After storing all the registers, FDIO calls FDENT to perform the requested operation. Following completion, FDIO examines the status to determine if an error occurred, and, if so, the operation may be retried. Generally, read/write operations will be retried up to five times before assuming a "hard" (ie: nontransient) error.

A nonrecoverable error is indicated with hexadecimal FF in the ERRCDE variable (see listing 2). This condition generally causes the application program to terminate so the error can be researched. The STATUS variable provides details about the specific problem.

Certain nonrecoverable conditions will not be retried. For example, a *busy* or *device not ready* condition causes an error condition without retry. The program can be altered to increase the sophistication to any level desired. Errors can be cataloged and recorded on another floppy disk to provide a history of all abnormal conditions.

	Variables (all values in hexadecimal)				
COMMAND	TRACK	SECTOR	BUFADR	BUFADR+1	TEST
02	—	—	—	—	RESTORE
1A	20	—	—	—	SEEK
16	10	—	—	—	VERIFY
8C	10	01	00	10	READ

Table 6: *Values to be set in variables for testing the controller (with the routine in listing 3). All values are listed in hexadecimal.*

Testing

After completing construction of the controller circuit and verifying the proper timing of the 74123 components, some simple tests can be performed to verify proper operation. These tests can be conducted with the aid of a simple program (listing 3) and table (table 6). Set your monitor to begin execution at INIT. When the break occurs, set the variables as shown for each specific test and allow program execution to continue. This procedure requires you to load the software previously discussed. Initial testing requires a *preformatted* IBM-compatible disk. Examination of the status byte following each test helps diagnose any existing problems.

The restore-drive procedure should generate stepping pulses that move the head to the track 0 position. The head-drive lead screw can be moved manually off the track 0 position to verify proper operation.

Directing the head to seek to a specific track requires the desired track value to be set in the data register of the 1771. This test also loads the head but does not attempt to perform a track verification. This test can be repeated several times with different track values to determine if the 1771 properly seeks in both directions.

If the controller moves the head correctly, the third test performs a track verification. Following the seek movement, the head is loaded, and the 1771 reads the address information recorded on the track to verify that it has located the proper track.

The fourth test attempts to read a specific sector. The data is stored beginning at location hexadecimal

Text continued on page 340

Listing 1: *Software to provide fundamental high-level operations for the disk controller (written for the 6502 microprocessor).*

```
FD400/FD1771B FLOPPY DISK CONTROL                                    PAGE    1

CARD # LOC     CODE       CARD  10        20        30        40        50        60        70
       0000                   .OPT  CNT,XREF,MEM,LIST,ERR,GEN
       0000            ;
       0000            ;  J.H.NICHOLSON 1-22-79
       0000            ;
       0000            ;
       0000            ;   THIS SEGMEMT PROVIDES BASIC CONTROL FUNCTIONS FOR EXECUTING
       0000            ;  COMMANDS TO A PERTEC FD400 FLOPPY DISK DRIVE CONTROLED WITH
       0000            ;  A WESTERN DIGITAL FD1771B-01 FLOPPY DISK CONTROLLER. THE BASIC
       0000            ;  ROUTINES PROVIDE AN INTERFACE VIA A 6520 PIA TO THE FD400/FD1771B
       0000            ;  SYSTEM.
       0000            ;   THE FD1771B COMMAND, TRACK, AND SECTOR VALUES ARE PROVIDED IN
       0000            ;  PAGE ZERO VARIABLES. THE COMMAND AND OTHER NECESSARY DATA IS
       0000            ;  WRITTEN TO THE FD1771B AND THE COMMAND IS EXECUTED. FOLLOWING
       0000            ;  THE COMPLETION OF THE COMMAND(INTRQ FROM FD1771B) THE STATUS,
       0000            ;  TRACK, AND SECTOR VALUES ARE READ FROM THE FD1771B. NO ERROR
       0000            ;  RECOVERY IS PERFORMED BY THIS SEGMEMT. IF THE DEVICE IS BUSY
       0000            ;  WHEN THIS SEGMENT IS GIVEN CONTROL, NORMAL COMPLETION ANALYSIS
       0000            ;  WILL BE DONE.
       0000            ;   TWO ENTRY POINTS TO THIS SEGMENT PROVIDE COMMAND EXECUTION AND
       0000            ;  PIA INITIALIZATION.
       0000            ;     FDENT.....ENTRY FOR FD1771B COMMAND EXECUTION.
       0000            ;     FDINT.....ENTRY FOR INITIALIZATION OF FD400/FD1771B.
       0000            ;
       0000            ;
       0000            ;   ALL FD1771B COMMANDS ARE VALID AND ARE LISTED BELOW BY FUNCTIONAL
       0000            ;  CATAGORY AS WELL AS TYPE GROUPS.
       0000            ;
       0000            ;   BASIC :  RESTORE              TYPE 1.  RESTORE
       0000            ;            STEP                           SEEK
       0000            ;            STEP IN                        STEP
       0000            ;            STEP OUT                       STEP IN
       0000            ;            FORCE INTRQ                    STEP OUT
       0000            ;
       0000            ;   READ  :  READ SECTOR          TYPE 2.  READ SECTOR
       0000            ;            READ TRACK                     WRITE SECTOR
       0000            ;            READ ADDR
       0000            ;                                 TYPE 3.  READ ADDR
       0000            ;   WRITE :  WRITE SECTOR                   READ TRACK
       0000            ;            WRITE TRACK                    WRITE TRACK
       0000            ;
       0000            ;   SEEK  :  SEEK                 TYPE 4.  FORCE INTRQ


FD400/FD1771B FLOPPY DISK CONTROL                                    PAGE    2

CARD # LOC     CODE       CARD  10        20        30        40        50        60        70
       0000            ;
       0000            ;
       0000            ;   WHEN GIVEN CONTROL, THIS SEGMENT ANALYZES THE COMMAND TYPE
       0000            ;  TO DETERMINE THE FUNCTIONS WHICH MUST BE PERFORMED. THE COMMANDS
       0000            ;  CAN BE SEGMENTED INTO FOUR LOGICAL FUNCTION GROUPS WHICH ARE
       0000            ;  SIMILAR TO THE FD1771B COMMAND TYPES.
       0000            ;
       0000            ;
       0000            ;   CMD TYPE                  FUNCTION
       0000            ;   --------                  --------
       0000            ;   TYPE 1(EX.SEEK)           BASIC FUNCTION
       0000            ;
       0000            ;   TYPE 1(SEEK)              WRITE NEW TRACK, THEN BASIC
       0000            ;
       0000            ;   TYPE 2                    WRITE SECTOR REGISTER
       0000            ;                             SPLIT TO READ OR WRITE
       0000            ;
       0000            ;   TYPE 3                    SPLIT TO READ OR WRITE
       0000            ;
       0000            ;   TYPE 4                    BASIC FUNCTION
       0000            ;
```

Listing 1 continued on page 308

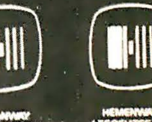
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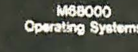












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Listing 1 continued:

```
0000                ;
0000                ;   BASIC FUNCTION :
0000                ;     1. WRITE COMMAND TO THE FD1771B.
0000                ;     2. WAIT FOR COMPLETION(INTRQ).
0000                ;     3. COMPLETION ANALYSIS(READ STATUS, TRACK, AND SECTOR)
0000                ;     4. EXIT
0000                ;
0000                ;   SEEK FUNCTION :
0000                ;     1. WRITE NEW TRACK TO DATA REGISTER.
0000                ;     2. WRITE SECTOR TO SECTOR REGISTER.
0000                ;     3. GO TO BASIC FUNCTION.
0000                ;
0000                ;   READ FUNCTION :
0000                ;     1. SEEK TO PROPER TRACK IF NECESSARY
0000                ;     2. WRITE SECTOR TO SECTOR REGISTER.
0000                ;     3. WRITE COMMAND TO FD1771B.
0000                ;     4. WAIT & LOOP FOR DRQ/INTRQ READING DATA ON DRQ.
0000                ;     5. ON INTRQ DO COMPLETION ANALYSIS(BASIC FCTN, STEP 3)
0000                ;
0000                ;   WRITE FUNCTION :
0000                ;     1. SEEK TO PROPER TRACK IF NECESSARY
0000                ;     2. WRITE SECTOR TO SECTOR REGISTER.
0000                ;     3. WRITE COMMAND TO FD1771B.
0000                ;     4. WAIT & LOOP FOR DRQ/INTRQ WRITING DATA ON DRQ.
0000                ;     5. ON INTRQ DO COMPLETION ANALYSIS(BASIC FCTN, STEP 3)
```

```
FD400/FD1771B FLOPPY DISK CONTROL                                PAGE    3

CARD # LOC     CODE      CARD   10         20         30         40         50         60         70
       0000             ;
       0000             ;  ******* 6520 PIA
       0000             ;
       0000             SADD    =$CC0C            6520 PIA A DATA DIRECTION
       0000             SAD     =$CC0C            6520 PIA A DATA REGISTER
       0000             CRA     =$CC0D            6520 PIA A CONTROL REGISTER
       0000             SBDD    =$CC0E            6520 PIA B DATA DIRECTION
       0000             SBD     =$CC0E            6520 PIA B DATA REGISTER
       0000             CRB     =$CC0F            6520 PIA B CONTROL REGISTER
       0000             ;
       0000             ;  ******* PIA CONNECTIONS
       0000             ;
       0000             ;   CA1 <-- UNUSED
       0000             ;   CA2 --> PULSE(¬RE CLR)
       0000             ;     PA7 <-> DAL7
       0000             ;     PA6 <-> DAL6
       0000             ;     PA5 <-> DAL5
       0000             ;     PA4 <-> DAL4
       0000             ;     PA3 <-> DAL3
       0000             ;     PA2 <-> DAL2
       0000             ;     PA1 <-> DAL1
       0000             ;     PA0 <-> DAL0
       0000             ;
       0000             ;     PB7 <-- INTRQ
       0000             ;     PB6 <-- DRQ
       0000             ;     PB5 --> READ
       0000             ;     PB4 --> WRITE
       0000             ;     PB3 --> ¬MR
       0000             ;     PB2 --> A1
       0000             ;     PB1 --> A0
       0000             ;     PB0 --> ¬ENABLE R/W
       0000             ;   CB1 <-- UNUSED
       0000             ;   CB2 --> DEVICE SELECT
       0000             ;
       0000             ;  ******* FD1771B COMMANDS
       0000             ;
       0000             FDRST   =$02              RESTORE
       0000             FDSK    =$12              SEEK
       0000             FDST    =$22              STEP
       0000             FDSTI   =$42              STEP IN
       0000             FDSTO   =$62              STEP OUT
       0000             FDRD    =$80              READ SECTOR
       0000             FDWT    =$A0              WRITE SECTOR
```

Listing 1 continued on page 310

Listing 1 continued:

```
     0000              FDRDA   =$C4           READ ADDRESS
     0000              FDRDT   =$E4           READ TRACK
     0000              FDWTT   =$F4           WRITE TRACK
     0000              FDFI    =$D0           FORCE INTERUPT
     0000              ;
     0000              ;  ******* COMMAND QUALIFIERS
     0000              ;
     0000              QV      =$04           VERIFY
     0000              QH      =$08           LOAD HEAD
     0000              QU      =$10           UPDATE TRK REG
     0000              QM      =$10           MULTIPLE RECORDS
     0000              QB      =$08           IBM FORMAT

  FD400/FD1771B FLOPPY DISK CONTROL                              PAGE    4

CARD # LOC      CODE      CARD  10       20       30      40       50       60       70
     0000              QS      =$01           NOT SYNC TO AM
     0000              QI0     =$01           NR TO R TRANS.
     0000              QI1     =$02           R TO NR TRANS.
     0000              QI2     =$04           INDEX PULSE
     0000              QI3     =$08           EACH 10 MS.
     0000              QE      =$04           ENABLE HLD + HLT DELAY
     0000              QFB     =$00           FB DATA MARK
     0000              QFA     =$01           FA DATA MARK
     0000              QF9     =$10           F9 DATA MARK
     0000              QF8     =$11           F8 DATA MARK
     0000              ;
     0000              ;  ******* INITIALIZATION CTL BYTES
     0000              ;
     0000              QCRC    =$F7           WRITE CRC
     0000              QIAM    =$FC           INDEX ADDR MARK
     0000              QIDM    =$FE           ID ADDR MARK
     0000              QAFB    =$FB           FB DATA MARK
     0000              QAFA    =$FA           FA. DATA MARK
```

Listing 1 continued on page 312

MULTI-USER OASIS HAS THE FEATURES PROS DEMAND. READ WHY.

(THEN COMPARE.)

Computer experts (the pros) usually have big computer experience. That's why when they shop system software for Z80 micros, they look for the big system features they're used to. And that's why they like Multi-User OASIS. You will too.

DATA INTEGRITY: FILE & AUTOMATIC RECORD LOCKING

The biggest challenge for any multi-user system is co-ordinating requests from several users to change the same record at the same time.

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Our File and Automatic Record Locking features solve these problems.

For example: normally all users can view a particular record at the same time. But, if that record is being updated by one user, automatic record locking will deny all other users access to the record until the up-date is completed. So records are always accurate, up-to-date and integrity is assured.

Pros demand file & automatic record locking. OASIS has it.

SYSTEM SECURITY: LOGON, PASSWORD & USER ACCOUNTING

Controlling who gets on your system and what they do once they're on it is the essence of system security.

Without this control, unauthorized users could access your programs and data and do what they like. A frightening prospect isn't it?

And multi-users can multiply the problem.

But with the Logon, Password and Privilege Level features of Multi-User OASIS, a system manager can specify for each user which programs and files may be accessed— and for what purpose.

Security is further enhanced by User Accounting—a feature that lets you keep a history of which user has been logged on, when and for how long.

Pros insist on these security features. OASIS has them.

EFFICIENCY: RE-ENTRANT BASIC

A multi-user system is often not even practical on computers limited to 64K memory.

OASIS Re-entrant BASIC makes it practical.

How?

Because all users use a single run-time BASIC module, to execute their compiled programs, less memory is needed. Even if you have more than 64K, your pay-off is cost saving and more efficient use of all the memory you have available—because it services more users.

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Listing 1 continued:

```
0000            QAF9    =$F9              F9 DATA MARK
0000            QAF8    =$F8              F8 DATA MARK
0000            ;
0000            ;   ******* PIA CONTROL COMMANDS(-MR ON)
0000            ;
0000            READ    =$29              READ FD1771B
0000            WRITE   =$19              WRITE FD1771B
0000            STAT    =$00              A1=0,A0=0   STATUS REGISTER
0000            TRK     =$02              A1=0,A0=1   TRACK REGISTER
0000            SECT    =$04              A1=1,A0=0   SECTOR REGISTER
0000            DATA    =$06              A1=1,A0=1   DATA REGISTER
0000            CMD     =$00              A1=0,A0=0   COMMAND REGISTER
0000            ;
0000            ;   ******* PAGE ZERO VARIABLES/EQUATES
0000            ;
0000            TIME1   *=*+1
0001            TIME2   *=*+1
0002                    *=$E0
00E0            DVCODE  *=*+1             DVC/FILE CODE
00E1            ERRCDE  *=*+1             ERROR CODE
00E2            COMAND  *=*+1 FD1771B COMMAND
00E3            STATUS  *=*+1         STATUS
00E4            TRACK   *=*+1         TRACK
00E5            SECTOR  *=*+1         SECTOR
00E6            FDBUF   *=*+2         BUFFER PTR
00E8            ;
00E8                    *=$200
```

```
 FD400/FD1771B FLOPPY DISK CONTROL                                       PAGE    5

CARD # LOC     CODE       CARD   10        20        30        40        50        60        70
       0200             ;
       0200             ;   ******* TYPE 1 COMMANDS
       0200             ;
       0200  A5 E2      TYPE1   LDA    COMAND      IF NOT SEEK
       0202  C9 20              CMP    #$20         ASSUME
       0204  B0 3A              BCS    BASIC         BASIC
       0206  C9 10              CMP    #$10        IF RESTORE
       0208  90 36              BCC    BASIC        ASSUME BASIC
       020A  A9 1F              LDA    #WRITE+DATA PIA CTL CMD
       020C  20 DE 02           JSR    SETUP       SET-UP PIA
       020F  A5 E4              LDA    TRACK       TRACK ADDR
       0211  C9 4D              CMP    #$4D        IF PAST END
       0213  B0 33              BCS    CMPANL       RETURN
       0215  20 CD 02           JSR    PULSE       WRITE TRACK
       0218  A9 1D              LDA    #WRITE+SECT PIA CTL CMD
       021A  20 DE 02           JSR    SETUP       SET-UP PIA
       021D  A5 E5              LDA    SECTOR      SECTOR ADDR
       021F  20 CD 02           JSR    PULSE       WRITE SECTOR
       0222  4C 40 02           JMP    BASIC       CONTINUE
       0225             ;
       0225             ;   ******* COMMAND ENTRY ANALYSIS
       0225             ;
       0225  A9 29      FDENT   LDA    #READ+STAT PIA CTL CMD          ** ENTRY **
       0227  20 DE 02           JSR    SETUP       SET-UP PIA
       022A  20 CD 02           JSR    PULSE       READ STATUS
       022D  6A                 ROR    A           IF DEVICE BUSY
       022E  B0 18              BCS    CMPANL       DO COMPLETION
       0230             ;
       0230             ;   ******* DETERMINE COMMAND TYPE
       0230             ;
       0230  A9 10              LDA    #$10        CMD MASK
       0232  24 E2              BIT    COMAND      CHECK FOR
       0234  10 CA              BPL    TYPE1        TYPE 1
       0236  50 23              BVC    TYPE2        TYPE 2
       0238  F0 4A              BEQ    RDATA        TYPE 3 READ
       023A  A9 20              LDA    #$20        SEPERATE
       023C  24 E2              BIT    COMAND       FORCE INTRQ FROM
       023E  D0 63              BNE    WDATA        TYPE 3 WRITE
       0240             ;
       0240             ;   ******* BASIC COMMAND PROCESS
       0240             ;
       0240  20 C2 02   BASIC   JSR    WRTCMD      WRITE CMD TO FD1771B
       0243  2C 0E CC           BIT    SBD         WAIT FOR
```

Listing 1 continued on page 314

Computers Designed for the Professional

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Listing 1 continued:

```
0246  10 FB            BPL   *-3         INTRQ
0248              ;
0248              ;  ******* COMPLETION ANALYSIS
0248              ;
0248  A0 02       CMPANL LDY  #2         LOOP CNT + INDEX
024A  98          CPLP   TYA             USE INDEX TO
024B  0A               ASL   A            SET A1,A0
024C  09 29            ORA   #READ       SET READ
024E  20 DE 02         JSR   SETUP       SET-UP PIA
0251  20 CD 02         JSR   PULSE       READ REGISTER
0254  99 E3 00         STA   STATUS,Y    STORE DATA
0257  88               DEY               DECR INDEX


  FD400/FD1771B FLOPPY DISK CONTROL                              PAGE    6

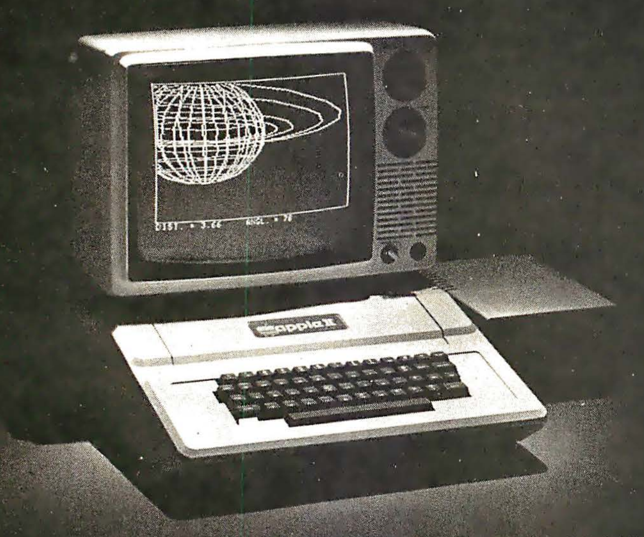
CARD # LOC    CODE      CARD  10       20       30       40       50       60       70
0258  10 F0            BPL   CPLP        CONTINUE
025A  60               RTS               RETURN
025B              ;
025B              ;  ******* TYPE 2 VERIFY TRACK
025B              ;
025B  A9 2B       TYPE2  LDA  #READ+TRK PIA CTL CMD
025D  20 DE 02         JSR   SETUP       SET-UP PIA
0260  20 CD 02         JSR   PULSE       READ TRACK
0263  C5 E4            CMP   TRACK       IF NOT EQUAL
0265  F0 0D            BEQ   TYPE2A       SEEK TO TRACK
0267  A5 E2            LDA   COMAND      SAVE COMMAND
0269  48               PHA                FOR LATER
026A  A9 12            LDA   #FDSK       SEEK COMMAND
026C  85 E2            STA   COMAND      SET IT
026E  20 25 02         JSR   FDENT       DO SEEK
0271  68               PLA               RESTORE
0272  85 E2            STA   COMAND       COMMAND
0274              ;
0274              ;  ******* TYPE 2 COMMANDS
0274              ;
0274  A9 1D       TYPE2A LDA  #WRITE+SECT PIA CTL CMD
0276  20 DE 02         JSR   SETUP       SET-UP PIA
0279  A5 E5            LDA   SECTOR      SECTOR ADDR
027B  20 CD 02         JSR   PULSE       WRITE SECTOR
027E  A9 20            LDA   #$20        SEPERATE
0280  24 E2            BIT   COMAND       READ
0282  D0 1F            BNE   WDATA         FROM WRITE
0284              ;
0284              ;  ******* READ DATA
0284              ;
0284  20 C2 02    RDATA  JSR  WRTCMD     WRITE COMMAND
0287  A0 00            LDY   #0          BUFFER INDEX
0289  A9 2F            LDA   #READ+DATA  PIA CTL CMD
028B  20 DE 02         JSR   SETUP       SET-UP PIA
028E  2C 0E CC    RDL    BIT  SBD        WAIT FOR          4
0291  30 B5            BMI   CMPANL       INTRQ OR         2
0293  50 F9            BVC   RDL           DRQ             2
0295  AD 0C CC         LDA   SAD         GET DATA BYTE     4      25 CYCLES
0298  49 FF            EOR   #$FF        INVERT DATA       2
029A  91 E6            STA   (FDBUF),Y   SAVE BYTE         6
029C  C8               INY               INCR BUFFER PTR   2
029D  D0 EF            BNE   RDL         IF ZERO           3 2
029F  E6 E7            INC   FDBUF+1      INCR BASE AND      5    + 9 CYCLES
02A1  D0 EB            BNE   RDL           CONTINUE          3
02A3              ;
02A3              ;  ******* WRITE DATA
02A3              ;
02A3  20 C2 02    WDATA  JSR  WRTCMD     WRITE COMMAND
02A6  A0 00            LDY   #0          BUFFER INDEX
02A8  A9 1F            LDA   #WRITE+DATA PIA CTL CMD
02AA  20 DE 02         JSR   SETUP       SET-UP PIA
02AD  B1 E6       WTL    LDA  (FDBUF),Y  GET DATA BYTE     6
02AF  49 FF            EOR   #$FF        INVERT DATA       2
02B1  8D 0C CC         STA   SAD         WRITE IT          4
02B4  2C 0E CC    WTL1   BIT  SBD        WAIT FOR          4      25 CYCLES
```

Listing 1 continued on page 317

The A2-3D1 Graphics Family...

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Circle 345 on inquiry card.

Listing 1 continued:

```
FD400/FD1771B FLOPPY DISK CONTROL                                    PAGE     7

LOC      CODE          CARD  10        20         30         40         50         60         70
02B7    30 8F              BMI    CMPANL       INTRQ OR            2
02B9    50 F9              BVC    WTL1          DRQ                2
02BB    C8                 INY                 INCR BUFFER PTR     2
02BC    D0 EF              BNE    WTL          IF ZERO             3 2
02BE    E6 E7              INC    FDBUF+1       INCR BASE AND        5    + 9 CYCLES
02C0    D0 EB              BNE    WTL            CONTINUE            3
02C2                  ;
02C2                  ;
02C2                  ;   ******* WRITE COMMAND TO FD1771B
02C2                  ;
02C2    A9 19         WRTCMD LDA  #WRITE+CMD  PIA CTL CMD
02C4    20 DE 02           JSR    SETUP        SET-UP PIA
02C7    A5 E2              LDA    COMAND       GET COMMAND
02C9    20 CD 02           JSR    PULSE         AND WRITE IT
02CC    60                 RTS                 RETURN
02CD                  ;
02CD                  ;   ******* ENABLE FD1771B READ/WRITE
02CD                  ;             (TRANSFER DATA)
02CD                  ;
02CD    49 FF         PULSE  EOR  #$FF         INVERT DATA
02CF    8D 0C CC           STA    SAD          DATA OUT
02D2    CE 0E CC           DEC    SBD          ENABLE
02D5    EE 0E CC           INC    SBD          READ/WRITE
02D8    AD 0C CC           LDA    SAD          DATA IN
02DB    49 FF              EOR    #$FF         INVERT DATA
02DD    60                 RTS                 CONTINUE
02DE                  ;
02DE                  ;   ******* SET UP PIA FOR READ/WRITE
02DE                  ;
02DE    A2 00         SETUP  LDX  #$00         ASSUME READ
02E0    8D 0E CC           STA    SBD          SET DVC CTL REG
02E3    0A                 ASL    A            CHECK
02E4    0A                 ASL    A             IF READ AND
02E5    30 01              BMI    SET1           SET FOR INPUT
02E7    CA                 DEX                 ADJUST DIR TO OUTPUT
02E8    A9 00         SET1   LDA  #0           SET CTL FOR
02EA    8D 0D CC           STA    CRA           DIR REGISTER
02ED    8E 0C CC           STX    SADD         SET DATA DIRECTION
02F0    A9 2C              LDA    #$2C         RESET PIA CTL
02F2    8D 0D CC           STA    CRA           TO DATA REG
02F5    60                 RTS                 RETURN
02F6                  ;
02F6                  ;   ******* DEVICE INITIALIZATION
```

Listing 1 continued on page 318

Listing 1 continued:

```
02F6                   ;
02F6  A2 00            FDINT  LDX    #$00       A DIR AS INPUT          ** ENTRY **
02F8  20 E8 02                JSR    SET1       SET-UP A SIDE
02FB  AD 0C CC                LDA    SAD        CLEAR -RE
02FE  A0 04                   LDY    #$04       CTL FOR B SIDE
0300  8C 0F CC                STY    CRB         DATA REGISTER
0303  86 E0                   STX    DVCODE     CLEAR DEVICE CODE
0305  E8                      INX               SET B SIDE
0306  8E 0E CC                STX    SBD         DATA REGISTER
0309  CA                      DEX               CTL FOR B SIDE
030A  8E 0F CC                STX    CRB         DIR REGISTER
030D  A2 3F                   LDX    #$3F       SET B SIDE


     FD400/FD1771B FLOPPY DISK CONTROL                              PAGE    8

CARD # LOC     CODE       CARD  10        20        30        40        50        60        70
       030F  8E 0E CC                STX    SBDD        DIR REGISTER
       0312  A2 3C                   LDX    #$3C       SELECT
       0314  8E 0F CC                STX    CRB         DEVICE 1
       0317  A9 02                   LDA    #FDRST     RESTORE CMD
       0319  85 E2                   STA    COMAND     SAVE IT
       031B  20 40 02                JSR    BASIC      RESTORE DEVICE 1
       031E  A2 34                   LDX    #$34       SELECT
       0320  8E 0F CC                STX    CRB         DEVICE 0
       0323  4C 40 02                JMP    BASIC      RESTORE DEVICE 0
       0326                   ;
       0326                   ;


     FLOPPY DISK I/O & ERROR RECOVERY                               PAGE    9

CARD # LOC     CODE       CARD  10        20        30        40        50        60        70
       0326                   ;
       0326                   ;
       0326                   ;
       0326                   ;  THIS SEGMENT PROVIDES FLOPPY DISK I/O OPERATIONS, USING
       0326                   ; THE FDENT ROUTINE, AND ERROR RECOVERY IS PERFORMED PRIOR TO
       0326                   ; RETURNING. COMMAND, TRACK, SECTOR, AND BUFFER ADDRESS ARE
       0326                   ; SET AS IF FDENT WERE TO BE USED. FDIO WILL SAVE ALL REGISTERS
       0326                   ; AS WELL AS PERFORMING ERROR RECOVERY. IF A COMMAND IS
       0326                   ; CONSIDERED RECOVERABLE, IT WILL BE RETRIED 5 TIMES PRIOR TO
       0326                   ; RETURNING A PERMANENT ERROR INDICATION IN ERRCODE($FF).
       0326                   ; A ZERO INDICATES A NORMAL COMPLETION OF THE I/O ACTIVITY.
       0326                   ; ADDITIONALLY THE PROPER FLOPPY DRIVE WILL BE SELECTED USING
       0326                   ; THE HIGH BIT OF DVCODE.
       0326                   ;
       0326                   ;  TYPE     MASK        ERROR
       0326                   ;
       0326                   ;  TYPE1    00011000    SEEK ERROR
       0326                   ;  WRITE    01111000    WRITE PROTECT/FAULT
       0326                   ;  READ     00011100    ID/REC NOT FOUND
       0326                   ;                        CRC ERROR
       0326                   ;                        LOST DATA
       0326                   ;
       0326                   ; ******* INITIALIZE AND EXEC CMD
       0326                   ;
       0326  48              FDIO    PHA               SAVE ACC               ** ENTRY **
       0327  98                      TYA               SAVE Y
       0328  48                      PHA                REGISTER
       0329  8A                      TXA               SAVE X
       032A  48                      PHA                REGISTER
       032B  A9 05                   LDA    #5         SET ERROR
       032D  85 E1                   STA    ERRCDE      COUNT
       032F  A9 34                   LDA    #$34       START W/DVC 0
       0331  24 E0                   BIT    DVCODE     IF NOT 0
       0333  50 02                   BVC    SETDVC      SET TO ONE
       0335  09 08                   ORA    #$08       SET DVC 1
       0337  8D 0F CC        SETDVC  STA    CRB        SET PIA
       033A  A5 E7           RETRY   LDA    FDBUF+1    SAVE ADDR HIGH
       033C  48                      PHA                FOR RECOVERY
       033D  A5 E5                   LDA    SECTOR     SAVE SECTOR
       033F  48                      PHA                FOR RECOVERY
       0340  20 25 02                JSR    FDENT      EXEC CMD
```

Listing 1 continued on page 320

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Listing 1 continued:

```
0343  38          SEC               ASSUME ERROR
0344           ;
0344           ;  ******* CHECK FOR BUSY/NOT READY
0344           ;
0344  A9 01        LDA   #$01      CHECK
0346  24 E3        BIT   STATUS     FOR
0348  D0 3F        BNE   ER1         BUSY OR
034A  30 3D        BMI   ER1          NOT READY
034C           ;
034C           ;  ******* DETERMINE CMD TYPE
034C           ;
034C  A9 10        LDA   #$10      CMD MASK
034E  24 E2        BIT   COMAND    SPLIT INTO
0350  10 19        BPL   TYP1       TYPE 1
```

```
FLOPPY DISK I/O & ERROR RECOVERY                                PAGE   10

CARD # LOC   CODE       CARD  10        20        30        40        50        60        70
       0352  50 29            BVC   TYP2       TYPE 2
       0354  F0 37            BEQ   RDT        TYPE 3 READ
       0356  A9 20            LDA   #$20      SEPERATE
       0358  24 E2            BIT   COMAND     FORCE INTRQ FROM
       035A  D0 27            BNE   WRT         TYPE 3 WRITE
       035C              ;
       035C              ;  ******* RETURN
       035C              ;
       035C  18          RTN1 CLC             NO ERROR
       035D  A9 00            LDA   #0        CLEAR
       035F  85 E1       RTN2 STA   ERRCDE     ERROR CODE
       0361  68               PLA             CLEAR STACK
       0362  85 E5            STA   SECTOR     OF SECTOR
       0364  68               PLA               AND ADDR HIGH
       0365  68          RTN3 PLA             RESTORE X
       0366  AA               TAX              REGISTER
       0367  68               PLA             RESTORE Y
       0368  A8               TAY              REGISTER
       0369  68               PLA             RESTORE ACC
       036A  60               RTS             RETURN
       036B              ;
       036B              ;  ******* TYPE 1 RECOVERY
       036B              ;
       036B  A9 18       TYP1 LDA   #$18      CHECK FOR
       036D  25 E3            AND   STATUS     BOTH CRC AND
       036F  F0 EB            BEQ   RTN1
       0371  C9 18            CMP   #$18        NOT FOUND
       0373  F0 14            BEQ   ER1          ERRORS
       0375  A9 30            LDA   #$30      STOP IF
       0377  24 E2            BIT   COMAND     STEP IN
       0379  D0 0E            BNE   ER1         OR STEP OUT
       037B  F0 26            BEQ   RDT1      RETRY SEEK AND RESTORE
       037D              ;
       037D              ;  ******* TYPE 2 SEPERATION
       037D              ;
```

Listing 1 continued on page 322

Circle 32 on inquiry card.

Listing 1 continued:

```
037D  A9 20      TYP2  LDA   #$20        SEPERATE
037F  24 E2            BIT   COMAND        READ
0381  F0 0A            BEQ   RDT             FROM WRITE
0383                   ;
0383                   ;  ******* WRITE RECOVERY
0383                   ;
0383  A9 60      WRT   LDA   #$60        ERROR MASK
0385  24 E3            BIT   STATUS      STOP IF WRITE
0387  F0 04            BEQ   RDT           PROTECT/FAULT
0389  A9 FF      ER1   LDA   #$FF        SET ERROR CODE
038B  D0 D2            BNE   RTN2        RETURN
038D                   ;
038D                   ;  ******* COMMON RECOVERY
038D                   ;
038D  A9 0C      RDT   LDA   #$0C        ERROR MASK
038F  24 E3            BIT   STATUS      IF ERROR
0391  D0 10            BNE   RDT1          RETRY
0393  A9 10            LDA   #$10        CHECK FOR
0395  24 E3            BIT   STATUS        NOT FND
0397  F0 C3            BEQ   RTN1            NONE RETURN


  FLOPPY DISK I/O & ERROR RECOVERY                                PAGE   11

CARD # LOC     CODE       CARD  10        20        30        40        50        60        70
0399                   ;                         IF MULTIPLE
0399  24 E2            BIT   COMAND        SECTOR OPERATION
039B  F0 06            BEQ   RDT1            CHECK
039D  A9 1B            LDA   #$1B              FOR END OF
039F  C5 E5            CMP   SECTOR              TRACK
03A1  F0 B9            BEQ   RTN1        CALL IT NORMAL
03A3                   ;
03A3                   ;  ******* CHECK ERROR COUNT
03A3                   ;
03A3  C6 E1      RDT1  DEC   ERRCDE      DECR ERROR CNT
03A5  10 05            BPL   RDT2        RETURN
03A7  68               PLA                 WITH
03A8  68               PLA                   ERROR
03A9  4C 65 03         JMP   RTN3              CONDITION
03AC                   ;
03AC                   ;  ******* RETRY OPERATION
03AC                   ;
03AC  68         RDT2  PLA               RESTORE
03AD  85 E5            STA   SECTOR        SECTOR
03AF  68               PLA               RESTORE
03B0  85 E7            STA   FDBUF+1       ADDR HIGH
03B2  4C 3A 03         JMP   RETRY       RETRY
```

Listing 1 continued on page 324

Circle 229 on inquiry card.

Listing 1 continued:

```
   FD400/FD1771B FLOPPY DISK FORMAT                                       PAGE   12

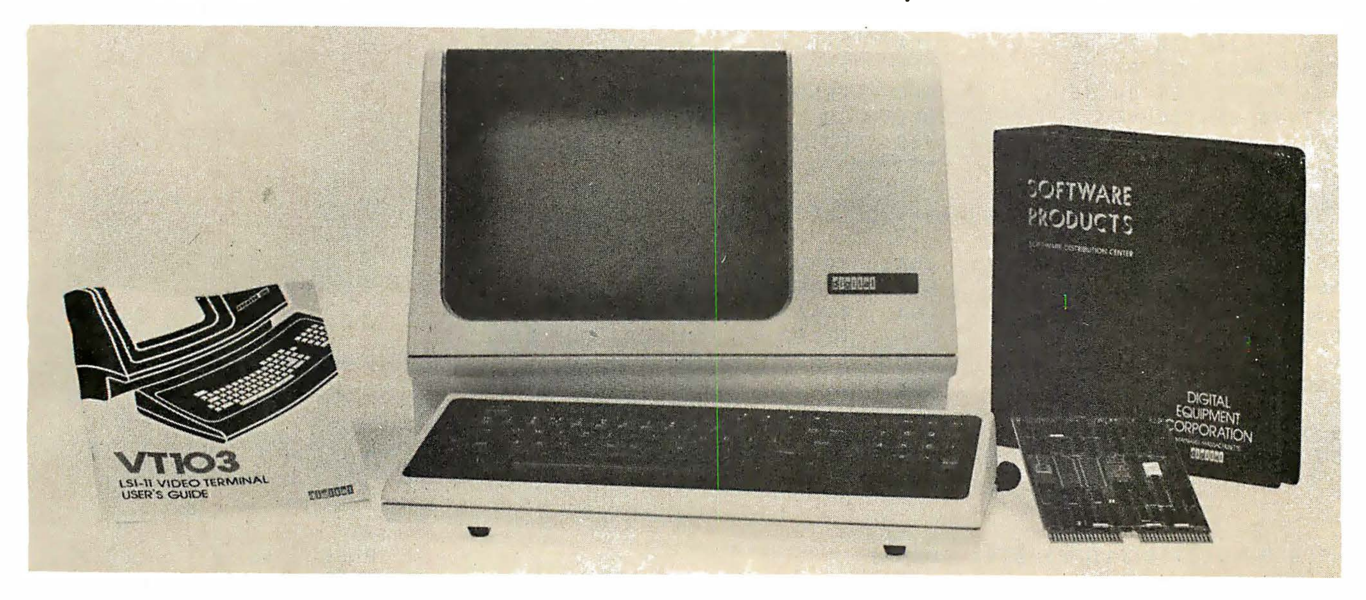
CARD # LOC     CODE        CARD  10        20        30        40        50        60        70
       03B5                ;
       03B5                ;
       03B5                ;  THIS SEGMENT FORMATS AN ENTIRE FLOPPY DISKETTE IN IBM COMPATIBLE
       03B5                ; SOFT SECTORING WITH 128 BYTE SECTORS. EACH SECTOR CONTAINS 80
       03B5                ; BYTES OF ASCII BLANK(X'20') FOLLOWED BY HEX ZEROS FOR THE
       03B5                ; REMAINDER OF THE SECTOR.
       03B5                ;
       03B5                ;
       03B5                ;
       03B5                ; ******* INITIALIZE
       03B5                ;
       03B5   20 F6 02     FORMAT JSR   FDINT       INIT SYSTEM         ** ENTRY **
       03B8   A2 00               LDX   #0          A SIDE
       03BA   8E 0D CC            STX   CRA          DIRECTION
       03BD   CA                  DEX               SET TO
       03BE   8E 0C CC            STX   SADD         OUTPUT
       03C1   A2 2C               LDX   #$2C        A SIDE
       03C3   8E 0D CC            STX   CRA          DATA
       03C6                ;
       03C6                ; ******* SET UP RECORD
       03C6                ;
       03C6   A9 4C               LDA   #$4C        SET
       03C8   8D 00 05            STA   REND         TRACK COUNT
       03CB   A9 FF               LDA   #$FF        SET TRK
       03CD   8D B3 05            STA   RTN          TO ZERO
       03D0   A9 FE        GO     LDA   #$FE        SET SECTOR
       03D2   8D B1 05            STA   RSN          TO ONE
       03D5   A2 1A               LDX   #$1A        SECTOR CNT
       03D7   A0 FD               LDY   #RSTRT-REND WRITE LENGTH
       03D9                ;
       03D9                ; ******* ISSUE WRITE TRACK
       03D9                ;
       03D9   A9 0B               LDA   #255-FDWTT STOR FD1771B
       03DB   8D 0C CC            STA   SAD          COMMAND
       03DE   A9 19               LDA   #WRITE+CMD STORE PIA
       03E0   8D 0E CC            STA   SBD          COMMAND
       03E3   CE 0E CC            DEC   SBD         ENABLE
       03E6   EE 0E CC            INC   SBD          READ/WRITE
       03E9   A9 1F               LDA   #WRITE+DATA STORE PIA
       03EB   8D 0E CC            STA   SBD          COMMAND
       03EE                ;
       03EE                ; ******* RECORD TRANSFER
       03EE                ;
       03EE   EE FE 05     WDT    INC   RSTRT+1     DELAY 6 CYCLES
       03F1   B9 00 05            LDA   REND,Y      STORE A
       03F4   8D 0C CC            STA   SAD          DATA BYTE
       03F7   2C 0E CC     WLP    BIT   SBD         WAIT FOR
       03FA   30 12               BMI   NEXT         INTRQ
       03FC   50 F9               BVC   WLP           OR DRQ
       03FE   88                  DEY               DECR INDEX
       03FF   D0 ED               BNE   WDT         CONTINUE
       0401   CE B1 05            DEC   RSN         INC SECTOR
       0404   A0 BA               LDY   #RNORM-REND INDEX VALUE
       0406   CA                  DEX               DECR SECTOR CNT
       0407   D0 E8               BNE   WDT+3       CONTINUE


   FD400/FD1771B FLOPPY DISK FORMAT                                       PAGE   13

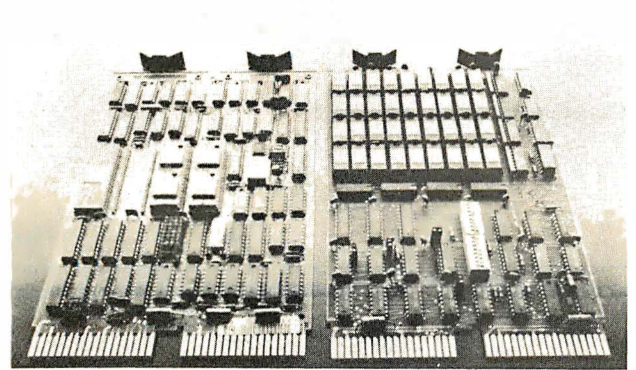
CARD # LOC     CODE        CARD  10        20        30        40        50        60        70
       0409                ;
       0409                ; ******* WAIT FOR COMPLETION
       0409                ;
       0409   2C 0E CC     TRKEND BIT   SBD         WAIT FOR
       040C   10 FB               BPL   TRKEND       INTRQ
       040E                ;
       040E                ; ******* MOVE TO NEXT TRACK
       040E                ;
       040E   20 35 04     NEXT   JSR   DELAY       DELAY 40 MS.
       0411   A9 B5               LDA   #255-FDSTI-QH STORE FD1771B
       0413   8D 0C CC            STA   SAD          COMMAND
       0416   A9 19               LDA   #WRITE+CMD STORE PIA
```

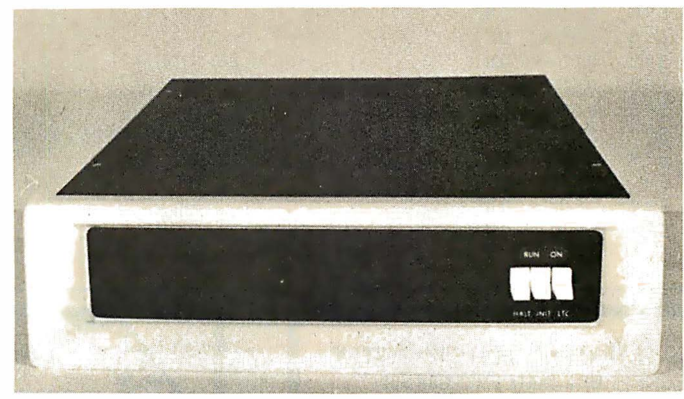
Listing 1 continued on page 326

LSI II/23® COMPUTER WITH 256KB MEMORY $5175.00



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Listing 1 continued:

```
569  0418  8D 0E CC          STA   SBD        COMMAND
570  041B  CE 0E CC          DEC   SBD       ENABLE
571  041E  EE 0E CC          INC   SBD        READ/WRITE
572  0421  2C 0E CC   SLP    BIT   SBD       WAIT FOR
573  0424  10 FB             BPL   SLP        INTRQ
574  0426  20 35 04          JSR   DELAY     DELAY 40 MS.
575  0429  CE B3 05          DEC   RTN       INCR TRACK
576  042C  CE 00 05          DEC   REND      DEC TRK CNT
577  042F  10 9F             BPL   GO        CONTINUE
578  0431  20 F6 02          JSR   FDINT     RESTORE DRIVE
579  0434  60                RTS             STOP
580  0435                ;
581  0435                ;   ******* DELAY 40 MS.
582  0435                ;
583  0435  A9 40      DELAY  LDA   #$40      MAJOR LOOP VALUE
584  0437  85 00             STA   TIME1     MAJOR LOOP CNT
535  0439  A9 4A      DL2    LDA   #$4A      MINOR LOOP VALUE
586  043B  85 01             STA   TIME2     MINOR LOOP CNT
587  043D  C6 01      DL1    DEC   TIME2     DECR MINOR CNT
588  043F  D0 FC             BNE   DL1       CONTINUE
589  0441  C6 00             DEC   TIME1     DECR MAJOR CNT
590  0443  D0 F4             BNE   DL2       CONTINUE
591  0445  60                RTS             RETURN
```

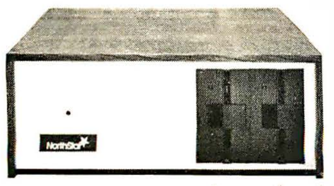
```
  FD400/FD1771B FLOPPY DISK FORMAT                                      PAGE    14

CARD # LOC     CODE       CARD  10        20        30        40        50        60        70
  593  0446                      *=*+255/256*256
  594  0500              ;
  595  0500              ;   ******* RECORD FORMAT
  596  0500              ;           (REVERSED AND INVERTED)
  597  0500  00          REND    .BYTE $00
  598  0501  00                  .BYTE $00,$00,$00,$00,$00,$00,$00,$00
  598  0502  00
  598  0503  00
  598  0504  00
  598  0505  00
  598  0506  00
  598  0507  00
  598  0508  00
  599  0509  00                  .BYTE $00,$00,$00,$00,$00,$00,$00,$00
  599  050A  00
  599  050B  00
  599  050C  00
  599  050D  00
  599  050E  00
```

Listing 1 continued on page 328

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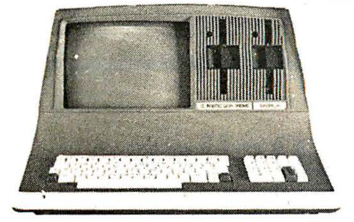
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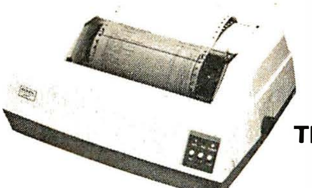


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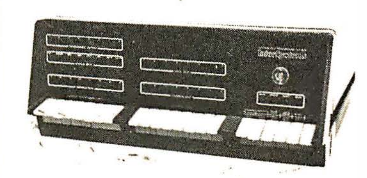


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Listing 1 continued:

```
599   050F   00
599   0510   00
600   0511   00                .BYTE  $00,$00,$00,$00,$00,$00,$00,$00
600   0512   00
600   0513   00
600   0514   00
600   0515   00
600   0516   00
600   0517   00
600   0518   00
601   0519   00                .BYTE  $00,$00,$00
601   051A   00
601   051B   00
602   051C   08                .BYTE  $08                                    DATA CRC
603   051D   FF                .BYTE  $FF,$FF,$FF,$FF,$FF,$FF,$FF,$FF
603   051E   FF
603   051F   FF
603   0520   FF
603   0521   FF
603   0522   FF
603   0523   FF
603   0524   FF
604   0525   FF                .BYTE  $FF,$FF,$FF,$FF,$FF,$FF,$FF,$FF
604   0526   FF
604   0527   FF
604   0528   FF
604   0529   FF
604   052A   FF
604   052B   FF
604   052C   FF
605   052D   FF                .BYTE  $FF,$FF,$FF,$FF,$FF,$FF,$FF,$FF
605   052E   FF
605   052F   FF
605   0530   FF
605   0531   FF
605   0532   FF
```

Listing 1 continued on page 330

Circle 316 on inquiry card.

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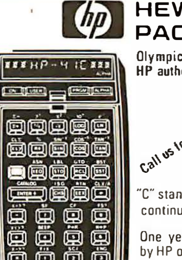
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Circle 262 on inquiry card.

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Listing 1 continued:

```
   FD400/FD1771B FLOPPY DISK FORMAT                                      PAGE   15

CARD # LOC     CODE        CARD  10        20        30        40        50        60        70
  605  0533   FF
  605  0534   FF
  606  0535   FF                 .BYTE $FF,$FF,$FF,$FF,$FF,$FF,$FF,$FF
  606  0536   FF
  606  0537   FF
  606  0538   FF
  606  0539   FF
  606  053A   FF
  606  053B   FF
  606  053C   FF
  607  053D   FF                 .BYTE $FF,$FF,$FF,$FF,$FF,$FF,$FF,$FF
  607  053E   FF
  607  053F   FF
  607  0540   FF
  607  0541   FF
  607  0542   FF
  607  0543   FF
  607  0544   FF
  608  0545   FF                 .BYTE $FF,$FF,$FF,$FF,$FF,$FF,$FF,$FF
  608  0546   FF
  608  0547   FF
  608  0548   FF
  608  0549   FF
  608  054A   FF
  608  054B   FF
  608  054C   FF
  609  054D   DF                 .BYTE $DF,$DF,$DF,$DF,$DF,$DF,$DF,$DF
  609  054E   DF
  609  054F   DF
  609  0550   DF
  609  0551   DF
  609  0552   DF
  609  0553   DF
  609  0554   DF
  610  0555   DF                 .BYTE $DF,$DF,$DF,$DF,$DF,$DF,$DF,$DF
  610  0556   DF
  610  0557   DF
  610  0558   DF
  610  0559   DF
  610  055A   DF
  610  055B   DF
  610  055C   DF
  611  055D   DF                 .BYTE $DF,$DF,$DF,$DF,$DF,$DF,$DF,$DF
  611  055E   DF
  611  055F   DF
  611  0560   DF
  611  0561   DF
  611  0562   DF
  611  0563   DF
  611  0564   DF
  612  0565   DF                 .BYTE $DF,$DF,$DF,$DF,$DF,$DF,$DF,$DF
  612  0566   DF
  612  0567   DF
  612  0568   DF
  612  0569   DF


   FD400/FD1771B FLOPPY DISK FORMAT                                      PAGE   16

CARD # LOC     CODE        CARD  10        20        30        40        50        60        70
  612  056A   DF
  612  056B   DF
  612  056C   DF
  613  056D   DF                 .BYTE $DF,$DF,$DF,$DF,$DF,$DF,$DF,$DF
  613  056E   DF
  613  056F   DF
  613  0570   DF
  613  0571   DF
  613  0572   DF
  613  0573   DF
  613  0574   DF
```

Listing 1 continued on page 332

Listing 1 continued:

```
 614  0575  DF                  .BYTE $DF,$DF,$DF,$DF,$DF,$DF,$DF,$DF
 614  0576  DF
 614  0577  DF
 614  0578  DF
 614  0579  DF
 614  057A  DF
 614  057B  DF
 614  057C  DF
 615  057D  DF                  .BYTE $DF,$DF,$DF,$DF,$DF,$DF,$DF,$DF
 615  057E  DF
 615  057F  DF
 615  0580  DF
 615  0581  DF
 615  0582  DF
 615  0583  DF
 615  0584  DF
 616  0585  DF                  .BYTE $DF,$DF,$DF,$DF,$DF,$DF,$DF,$DF
 616  0586  DF
 616  0587  DF
 616  0588  DF
 616  0589  DF
 616  058A  DF
 616  058B  DF
 616  058C  DF
 617  058D  DF                  .BYTE $DF,$DF,$DF,$DF,$DF,$DF,$DF,$DF
 617  058E  DF
 617  058F  DF
 617  0590  DF
 617  0591  DF
 617  0592  DF
 617  0593  DF
 617  0594  DF
 618  0595  DF                  .BYTE $DF,$DF,$DF,$DF,$DF,$DF,$DF,$DF
 618  0596  DF
 618  0597  DF
 618  0598  DF
 618  0599  DF
 618  059A  DF
 618  059B  DF
 618  059C  DF
 619  059D  04                  .BYTE $04                          DATA AM
 620  059E  FF                  .BYTE $FF,$FF,$FF,$FF,$FF,$FF      DATA FLD SYNC
 620  059F  FF
 620  05A0  FF


  FD400/FD1771B FLOPPY DISK FORMAT                               PAGE   17

CARD # LOC    CODE      CARD  10        20        30        40        50        60        70
 620  05A1  FF
 620  05A2  FF
 620  05A3  FF
 621  05A4  00                  .BYTE $00,$00,$00,$00,$00,$00      DATA
 621  05A5  00
 621  05A6  00
 621  05A7  00
 621  05A8  00
 621  05A9  00
 622  05AA  00                  .BYTE $00,$00,$00,$00,$00           GAP
 622  05AB  00
 622  05AC  00
 622  05AD  00
 622  05AE  00
 623  05AF  08                  .BYTE $08                          ADDR CRC
 624  05B0  FF          RSL     .BYTE $FF                          SECTOR LENGTH
 625  05B1  FE          RSN     .BYTE $FE                          SECTOR ADDR
 626  05B2  FF                  .BYTE $FF                          ZERO
 627  05B3  FF          RTN     .BYTE $FF                          TRACK ADDR
 628  05B4  01                  .BYTE $01                          ID AM
 629  05B5  FF                  .BYTE $FF,$FF,$FF,$FF,$FF,$FF      ADDR SYNC
 629  05B6  FF
 629  05B7  FF
 629  05B8  FF
 629  05B9  FF
```

Listing 1 continued on page 334

Does timesharing on a small system make sense?



It does with OS-9™ Level One!

Now two (or more) acts can share your microcomputer stage. You will no longer have to walk away from your computer while it is busy running a long program. Because OS-9 is a multitasking operating system, you can be running a BASIC program while editing a PASCAL program, for example. This lets you make more efficient use of your time and your system, even if you only use one terminal. If your application requires multiple, independent terminals, one OS-9 system can do the work of several single-user systems.

The convenience of an advanced operating system

Sophistication does not require complexity. Many OS-9 users say that it is actually easier to use than the older 6800-type operating systems. Consider how easy it is to run multiple programs: to run a program you just type its name and hit 'return.' To run a program as a separate job, you type its name, an '&' character, then hit return. The program runs as usual, but OS-9 comes back immediately and is ready for your next command. Simple commands let you see each program's status, set its priority, or abort it.

The file management system has fast, byte-addressable random-and sequential-access files. The tree-structured multiple directory system lets you create separate disk directories for each user, project, or application. Command line I/O file redirection means you specify what device and/or files a program will use when you run it, not when you write it.

Efficiency and hardware versatility

No other operating system can run on such a broad range of hardware: the overall RAM requirement for Level One is 32K to 56K RAM. Memory utilization is superlative because OS-9 lets multiple tasks "share" the same reentrant program. For example, if two users run BASIC09, only one "copy" is actually loaded into memory. The Level Two version of OS-9 can utilize up to a megabyte of memory on systems having memory management hardware (both versions come with complete timesharing support).

OS-9's device independent I/O system can handle almost any number and combination of I/O devices: five or eight inch diskettes, winchester disks, disk cartridges, serial and parallel ports, memory-mapped video displays, and more.

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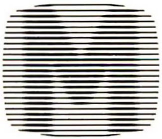
Each OS-9 package comes with a User's Manual and a System Programmer's Manual that cover every aspect of OS-9. If you have special requirements, you can even purchase the Source Code for most of OS-9 and related software. At Microware® we take pride in offering the best customer support in the business. Technical advice and assistance by phone, mail or telex is available during all business hours.

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Circle 239 on inquiry card.

Listing 1 continued:

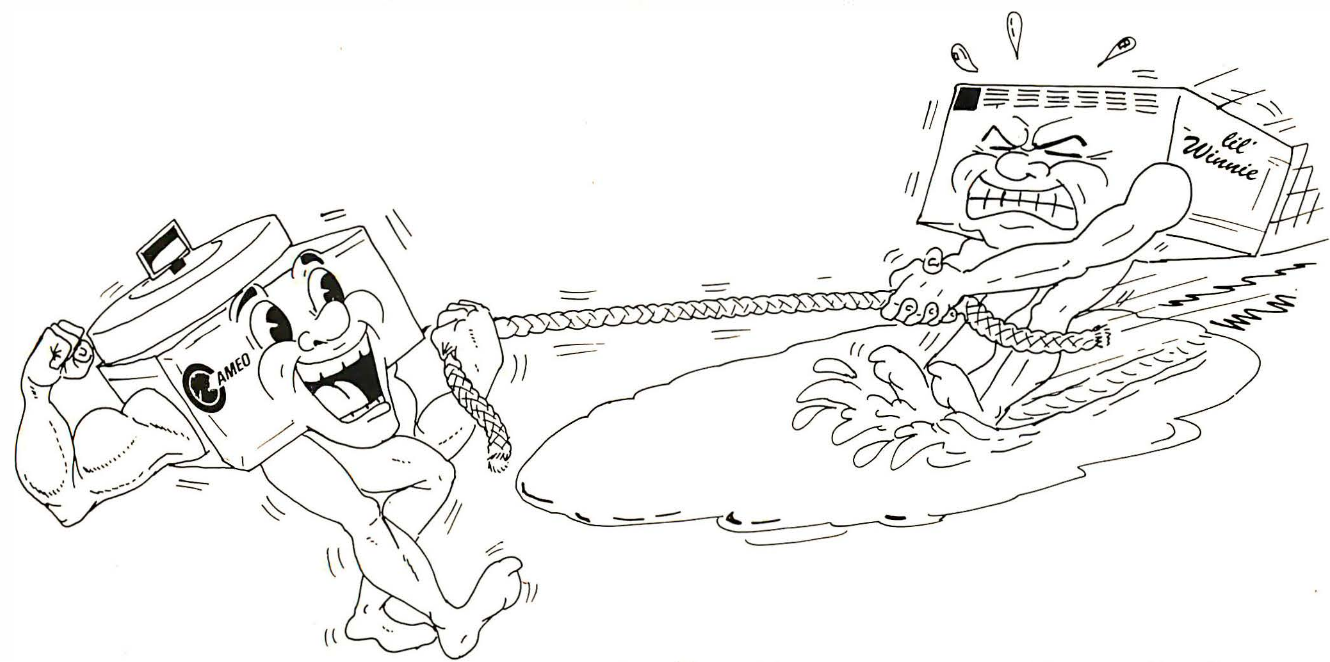
```
  629   05BA   FF
  630   05BB                RNORM   =*-1
  631   05BB   00                   .BYTE  $00,$00,$00,$00,$00,$00,$00,$00
  631   05BC   00
  631   05BD   00
  631   05BE   00
  631   05BF   00
  631   05C0   00
  631   05C1   00
  631   05C2   00
  632   05C3   00                   .BYTE  $00,$00,$00,$00,$00,$00,$00,$00
  632   05C4   00
  632   05C5   00
  632   05C6   00
  632   05C7   00
  632   05C8   00
  632   05C9   00
  632   05CA   00
  633   05CB   00                   .BYTE  $00,$00,$00,$00,$00,$00,$00,$00
  633   05CC   00
  633   05CD   00
  633   05CE   00
  633   05CF   00
  633   05D0   00
  633   05D1   00
  633   05D2   00
  634   05D3   00                   .BYTE  $00,$00
  634   05D4   00
  635   05D5   03                   .BYTE  $03                        INDEX MARK
  636   05D6   00                   .BYTE  $00,$00,$00,$00,$00,$00,$00,$00


   FD400/FD1771B FLOPPY DISK FORMAT                                  PAGE   18

CARD # LOC     CODE       CARD  10        20        30        40        50        60        70
  636   05D7   00
  636   05D8   00
  636   05D9   00
  636   05DA   00
  636   05DB   00
  636   05DC   00
  636   05DD   00
  637   05DE   00                   .BYTE  $00,$00,$00,$00,$00,$00,$00,$00
  637   05DF   00
  637   05E0   00
  637   05E1   00
  637   05E2   00
  637   05E3   00
  637   05E4   00
  637   05E5   00
  638   05E6   00                   .BYTE  $00,$00,$00,$00,$00,$00,$00,$00
  638   05E7   00
  638   05E8   00
  638   05E9   00
  638   05EA   00
  638   05EB   00
  638   05EC   00
  638   05ED   00
  639   05EE   00                   .BYTE  $00,$00,$00,$00,$00,$00,$00,$00
  639   05EF   00
  639   05F0   00
  639   05F1   00
  639   05F2   00
  639   05F3   00
  639   05F4   00
  639   05F5   00
  640   05F6   00                   .BYTE  $00,$00,$00,$00,$00,$00,$00,$00
  640   05F7   00
  640   05F8   00
  640   05F9   00
  640   05FA   00
  640   05FB   00
  640   05FC   00
  640   05FD   00
  641   05FE                RSTRT   =*-1
  642   05FE                        .END
```

Listing 1 continued on page 336

It's not hard to win . . .



with fast, reliable, mass storage

- The Cameo cartridge disk subsystem provides 40 to 100 times the storage capacity of floppy disks. Data transfer rates and reliability are correspondingly faster.
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*REGISTERED TRADE MARKS

Circle 49 on inquiry card.

Listing 1 continued:

```
END OF MOS/TECHNOLOGY 650X ASSEMBLY VERSION 5
NUMBER OF ERRORS =    0,  NUMBER OF WARNINGS =    0


        SYMBOL TABLE

SYMBOL    VALUE   LINE DEFINED        CROSS-REFERENCES

BASIC     0240        233    197   199   210   362   365
CMD       0000        175    312   536   568
CMPANL    0248        239    204   218   282   302
COMAND    00E2        184    195   223   228   257   260   263   272   314   361   422
                             427   453   460   480
CPLP      024A        240    247
CRA       CC0D         96    338   341   515   519
CRB       CC0F         99    350   355   359   364   404
DATA      0006        174    200   279   296   540
DELAY     0435        583    565   574
DL1       043D        587    588
DL2       0439        585    590
DVCODE    00E0        182    351   401
ERRCDE    00E1        183    399   434   488
ER1       0389        468    416   417   451   454
FDBUF     00E6        188    286   289   298   306   405   499
FDENT     0225        214  . 261   409
FDFI      00D0        137   ****
FDINT     02F6        346    513   578
FDIO      0326        393   ****
FDRD      0080        132   ****
FDRDA     00C4        134   ****
FDRDT     00E4        135   ****
FDRST     0002        127    360
FDSK      0012        128    259
FDST      0022        129   ****
FDSTI     0042        130    566
FDSTO     0062        131   ****
FDWT      00A0        133   ****
FDWTT     00F4        136    534
FORMAT    03B5        513   ****
GO        03D0        527    577
NEXT      040E        565    549
PULSE     02CD        321    205   209   216   244   254   270   315
QAFA      00FA        163   ****
QAFB      00FB        162   ****
QAF8      00F8        165   ****
QAF9      00F9        164   ****
QB        0008        145   ****
QCRC      00F7        159   ****
QE        0004        151   ****
QFA       0001        153   ****
QFB       0000        152   ****
QF8       0011        155   ****
QF9       0010        154   ****
QH        0008        142    566
QIAM      00FC        160   ****
QIDM      00FE        161   ****
QI0       0001        147   ****
QI1       0002        148   ****
QI2       0004        149   ****
QI3       0008        150   ****
QM        0010        144   ****
QS        0001        146   ****


SYMBOL    VALUE   LINE DEFINED        CROSS-REFERENCES

QU        0010        143   ****
QV        0004        141   ****
RDATA     0284        277    226
RDL       028E        281    283   288   290
RDT       038D        473    425   461   467
RDT1      03A3        488    455   475   481
RDT2      03AC        496    489
READ      0029        169    214   242   252   279
```

Listing 1 continued on page 338

IF YOU CAN WAIT A MINUTE, WE CAN SAVE YOU $1,000.

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A business letter, written on a 45 cps word-processing printer, might take about two minutes to print.

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Circle 191 on inquiry card.

Listing 1 continued:

```
REND        0500          597   524   546   576   530   554
RETRY       033A          405   500
RNORM       05BA          630   554
RSL         05B0          624  ****
RSN         05B1          625   528   553
RSTRT       05FD          641   530   545
RTN         05B3          627   526   575
RTN1        035C          432   449   478   484
RTN2        035F          434   469
RTN3        0365          438   492
SAD         CC0C           95   284   300   322   325   348   535   547   567
SADD        CC0C           94   339   517
SBD         CC0E           98   234   281   301   323   324   332   353   537   538   539
                                541   548   560   569   570   571   572
SBDD        CC0E           97   357
SECT        0004          173   206   267
SECTOR      00E5          187   208   269   407   436   483   497
SETDVC      0337          404   402
SETUP       02DE          331   201   207   215   243   253   268   280   297   313
SET1        02E8          337   335   347
SLP         0421          572   573
STAT        0000          171   214
STATUS      00E3          185   245   415   448   466   474   477
TIME1       0000          179   584   589
TIME2       0001          180   586   587
TRACK       00E4          186   202   255
TRK         0002          172   252
TRKEND      0409          560   561
TYPE1       0200          195   224
TYPE2       025B          252   225
TYPE2A      0274          267   256
TYP1        036B          447   423
TYP2        037D          459   424
WDATA       02A3          294   229   273
WDT         03EE          545   552   556
WLP         03F7          548   550
WRITE       0019          170   200   206   267   296   312   536   540   568
WRT         0383          465   428
WRTCMD      02C2          312   233   277   294
WTL         02AD          298   305   307
WTL1        02B4          301   303

INSTRUCTION  COUNT

    ADC          0
    AND          1
    ASL          3
    BCC          1
    BCS          3
    BEQ         11
    BIT         19
    BMI          5
    BNE         15
    BPL          8
    BRK          0
    BVC          6
    BVS          0
    CLC          1
    CLD          0
    CLI          0
    CLV          0
    CMP          6
    CPX          0
    CPY          0
    DEC          9
    DEX          4
    DEY          2
    EOR          4
    INC          6
    INX          1
    INY          2
    JMP          4
    JSR         27
    LDA         52
    LDX          8
    LDY          6
```

Listing 1 continued on page 340

Listing 1 continued:

```
        LSR          0
        NOP          0
        ORA          2
        PHA          6
        PHP          0
        PLA         10
        PLP          0
        ROL          0
        ROR          1
        RTI          0
        RTS          7
        SBC          0
        SEC          1
        SED          0
        SEI          0
        STA         27
        STX         10
        STY          1
        TAX          1
        TAY          1
        TSX          0
        TXA          1
        TXS          0
        TYA          2

 # SYMBOLS =  101 (LIMIT =  800)     # BYTES =  837 (LIMIT = 8192)


# LINES =  853 (LIMIT = 3000)     # XREFS =  257 (LIMIT = 1600)
```

Listing 2: *Example of a routine that reads disk track 3 into memory, starting at location hexadecimal 1000. This routine also illustrates the use of the ERRCDE variable.*

```
JSR FDINT         Initialize
LDA #$9C          Read multiple
STA COMMAND          sector command
LDA #$03          Request track
STA TRACK            number 3
LDA #0            Set buffer
STA FDBUF            address
LDA #$10                at
STA FDBUF + 1                hexadecimal 1000
JSR FDIO          Do I/O
LDA STATUS           check for
BNE ERROR               error
    .
    .
    .
```

Listing 3: *Simple testing program for a disk controller/6502 microprocessor combination. When the BRK (break) occurs, the variables listed in table 6 can be set to test the various controller functions.*

```
INIT    JSR FDINT
        BRK
        BRK
GO      JSR FDENT
        BRK
        BRK
        JMP GO
```

Text continued from page 304:

1000. The status byte indicates if the read operation was successful. If the read test appears good, various other commands should be attempted to increase your familiarity with the 1771 and drive operation.

Extensions

With the addition of an external multiplexing circuit to switch the floppy-disk control lines, multiple drives can be controlled. Multiple drives, however, add a new software-control problem. Since the 1771 retains the current head location, it is necessary to update the track register when switching between drives. A memory variable to contain the head location of each drive can be used to adjust the 1771's register.

A simplified version of the floppy-disk controller can be used to operate 5-inch disk drives in either single- or dual-density. In addition, this disk design is extensible to a more elaborate controller that uses a dedicated 6502 to communicate over a parallel or serial interface to a host computer.

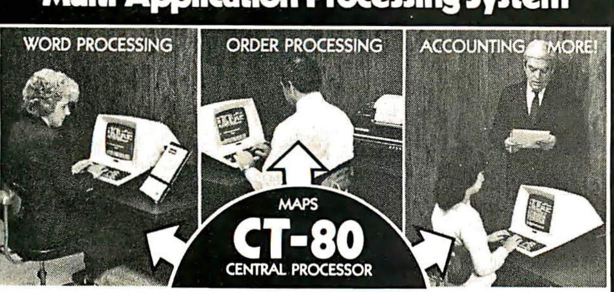
Conclusion

Floppy-disk drives provide sufficient capacity and performance to meet the needs of most microcomputer users. By combining hardware and software, a floppy-disk system can be constructed economically without sacrificing any function or performance. The 6502 microprocessor, with a few hundred bytes of program, can control head movement and data transfer by utilizing the 1771 controller. The software provides a flexible, yet economic, solution to mass-storage problems.■

Circle 110 on inquiry card.

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- 8088 CPU
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LDPI 8088 MAINFRAME

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Circle 202 on inquiry card.

Ask BYTE

Conducted by Steve Ciarcia

Easy Data Entry?

Dear Steve,

I enjoyed your article "Build a Low-Cost, Remote Data-Entry Terminal." (See the September 1980 BYTE, page 26.) Your idea is close to the type of device I need: a simple data-entry terminal that has a ten-character display and can be used to record data, ten characters at a time, using an audio-cassette recorder. Is there an easy way to use your device for this?

Roy Pittman
Stillwater OK

The remote data-entry terminal described in that article will do some of the things you want, but not everything. It cannot support more than an 8-bit display without circuit modification. It can, however, easily store and send up to fourteen characters entered sequentially on the keypad (refer to the last paragraph, on page 32 of the article).

Although it is a little involved and requires some extra button pushes to load the characters, the data-entry terminal could be used as you have suggested. To do it, you first press the Control-Escape to enter the storage mode (the remote terminal sends a hexadecimal FA output to the recorder). Decoding the FA code will allow automatic turn-on of the recorder. The next one to fourteen keys pressed will be stored. They are automatically sent as a single message when a Control-semicolon is typed.

As designed, the data rate is 1200 bps (bits per second). To lower the data rate to something more manageable, say 300 bps, you simply lower the crystal frequency proportionately. To remotely switch a tape recorder on and off, you can use the keyboard function decoder that I described in a previous article. (See "Build a Keyboard Function Decoder," July 1978 BYTE, page 98.) . . . **Steve**

Backup Supplies

Dear Steve,

Allow me to add another request for backup power supplies. I want to use a computer for Bible translating for tribal people, but our electric power not only blacks out for a few minutes to several days, but when the local welder starts work, the lights dim each time he strikes an arc.

My son had a computer damaged when a copying machine was turned on, so I wonder about the welder. I had decided on a solution similar to the ideas you have mentioned, but I felt that I couldn't design a sine-wave inverter and that a computer probably wouldn't accept the square wave from a Heathkit inverter. How about the motor/generator rigs used by the military for B+ power supplies? A 1974 McMaster-Carr catalog shows that they were available in 24, 28, 32, 63, and 110 VDC input and 250 to 2000 W output at 115 V 60 Hz. Prices ranged from $200 to $600.

Of course, this wouldn't be as efficient as a solid-state inverter, and would need maintenance (since the rigs have brushes) but it might be easier and cheaper to buy equipment on the surplus market.

Also, who publishes *Digital Design*?

Russell Reed
Pinamalayan, Oriental Mindoro, Philippines

Motor/generator combinations are definitely a reasonable backup power system. That was all there was before solid-state converters. I cannot speak for the condition of a World War II surplus unit, but if it operates, it can be an economical solution to your problem. In fact, many computer manufacturers (such as Control Data) frequently use motor/generators in their installations. Be careful to monitor the output frequency as well as the voltage when you first start it. The years may have taken their toll on the regulator section.

Digital Design *is published by Benwill Publishing Corporation, 1050 Commonwealth Ave, Boston MA 02215. The issue covering uninterruptible power supplies was February 1980 (Volume 10, Number 2).* . . . **Steve**

Bank Switching

Dear Steve,

With the recent price reduction of dynamic memory circuits, a 64 K-byte memory system can be built with 32 devices (at $96) or 128 devices (for $64). I read BYTE and other fine publications and I keep coming across an interesting concept called bank switching. What exactly is bank switching? Also, an idea I have is to latch the data at a port bus to provide a

Circle 37 on inquiry card.



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- RS204 TRS-80 Model III 129
- RS205 Radio Shack Color Computer 89
- P401 Paper Tiger 440/445/460 99
- P402 Centronics 730/737 - Line Printer II/IV 89
- P403 Epson MX70 or MX80 89
- CC90 Matching Attaché Case 75



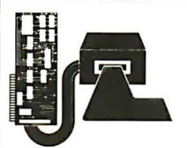
5650 INDIAN MOUND CT. COLUMBUS, OHIO 43213 (614) 868-9464



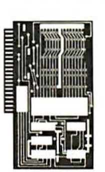
Circle 70 on inquiry card.

Measure, Control, Document...

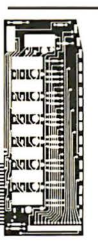
Computer Systems and Peripherals designed to coordinate with the Apple Computers that let you measure, monitor, regulate, control and document with laboratory precision, at affordable cost.



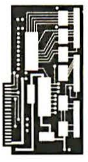
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Monitor 16 separate inputs under program control
Choose from 8 voltage ranges under program control; 100mV to 10V
Make a reading in 20 microseconds



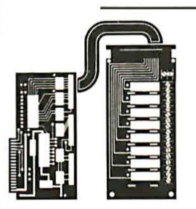
AI02 Analog Input System (A/D,8bits)
Measure voltages with 0.4% precision
Monitor 16 separate inputs under program control
Match most sensors with a standard 5 volt range
Signal Conditioning System SC14 available



A003 Analog Output System (D/A, 8 bits)
Control voltage levels from a simple program
Conversion in less than 3 μsec.
Standard 0 to 10 V Range
Jumpers select 0 to 5V or 5 to 5V
2, 4, or 8 channel models
Each channel has its own memory
Each channel has range, offset adjustments



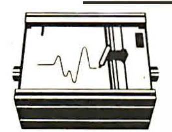
DI09 Digital Interface
Monitor or control 32 circuits in any combination
Measure time intervals or count pulses
Plug into BCD, parallel, or switch closure instrument outputs



UI16 Isolated Power Interface
Control 110VAC circuits from a program
Operate DC relays or solenoids
Receive logic pulses in noisy environments
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Start with one circuit — expand to dozens



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Circle 179 on inquiry card.

Ask BYTE

total address bus of 24 bits. Can I do this?
Simon Chapman
Petaluma CA

Memory is indeed becoming inexpensive these days. Many personal computers will soon contain more than 64 K bytes of memory. To use the extra memory, they must, of course, use bank switching.

A bank of memory is some portion of memory that can be directly addressed by the processor. If you had an Apple II computer with 48 K bytes of memory, all 64 K bytes (including read-only memory) would be in the same bank of memory. Addressing the 64 K requires 16 address bits. If you were to add another 64 K of directly addressable memory, 17 bits would be required. Since the 6502 microprocessor (and the Z80 for that matter) has only 16 address bits, the additional bit must be created under program control.

The typical method is to dedicate a latched output port to this function. To access this second bank of memory, a program in the first bank sets the port output high, simulating the seventeenth address bit. The computer then works exclusively in the second bank. To return to the first bank, a program in the second bank resets the port to a low level.

As you can see, it can get complicated switching back and forth. Mirror images of the operating-system software would have to be resident in both banks. The solution to this problem is to bank-switch memory in 32 K-byte increments rather than 64 K bytes. The typical system would have the first 32 K-byte bank contain the operating system and switch up to eight individual 32 K banks occupying the second 32 K range. Activation of one of the eight boards is handled by setting a bit on an output port (each bit is a separate memory-bank enable) through the always resident operating system. In most cases, the bank-switching is transparent to the user and takes only a few instructions.

Perhaps as soon as I get some of the new 64 K-byte integrated circuits, I'll discuss this topic in greater depth in an article. . . . **Steve**

Computer Stores

Dear Steve,

I have a degree in electronics and my fiancée has a degree in business management. We live in a small town and would like to open a computer store, for small businesses, homes, and industry. Where can I get some help and ideas on getting started? There are no computer-related jobs around here, and I feel like I'm being left out.
Bill Bass
Bristol TN

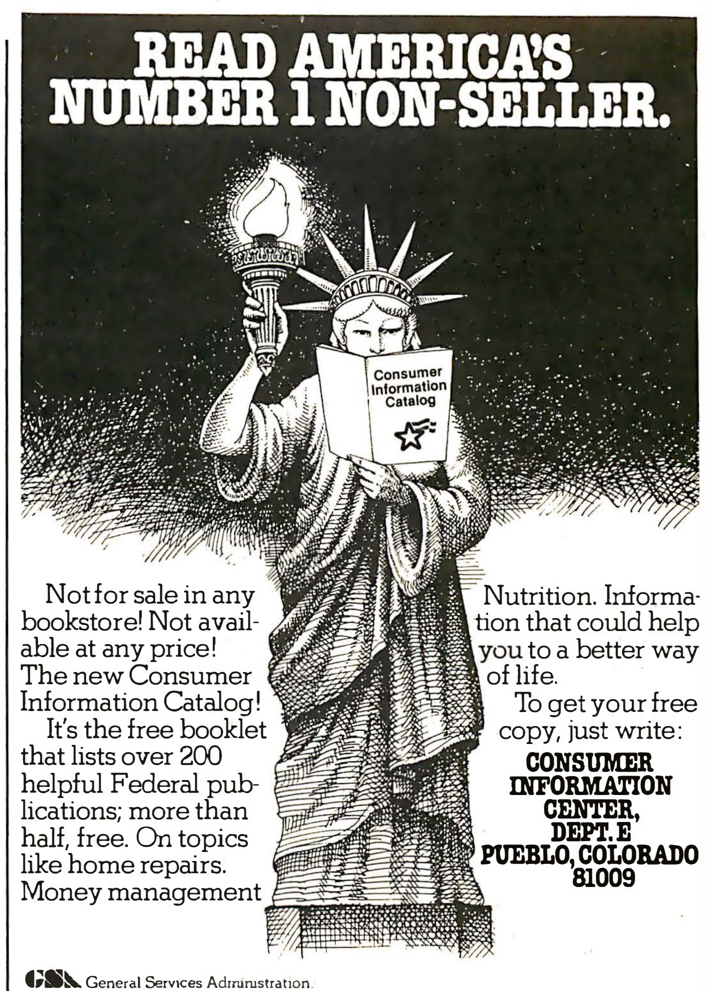
Starting a computer store is a costly and tough job. When you first open a computer store, most personal-computer manufacturers will only ship cash-on-delivery, and many items must be in stock for you to sell them. When hobbyists walk into a computer store, rather than ask if you sell it, most will ask if you have it in stock. Your advantage is not price—mail-order houses are generally much cheaper—so it must be demonstration and availability that sells your products.

Turnover of stock is the key to success. Make sure there is a large enough market in your area before committing to this endeavor, and only believe about a quarter of the people who say they will buy something from you if you open a store.

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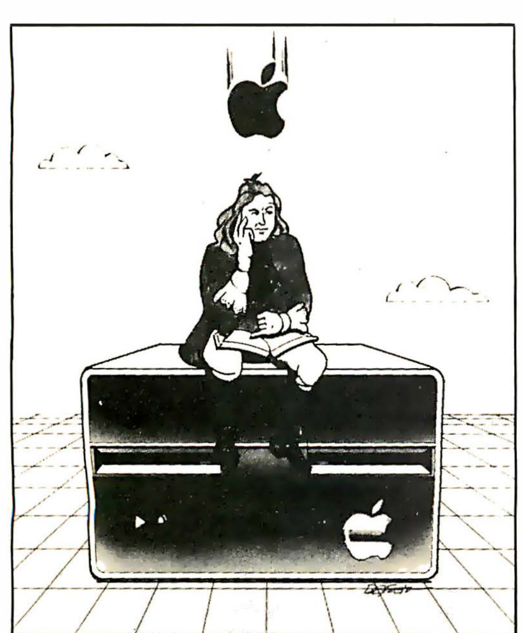
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Circle 304 on inquiry card.

puter store is to visit one in another town (make sure it's not close enough to be a competitor) and ask the owner the questions you are posing to me. This is a new field and, unfortunately, there are as many failures as there are successes. Be careful, but don't hesitate to strike out on your own. . . . **Steve**

Double Characters

Dear Steve,

I would like to acquire a home terminal, since terminal time at school is sometimes difficult to get. Is it possible to build a circuit to connect between the output of a TRS-80 Color Computer or a Videotex and my television or monitor that would double the number of characters per line that these machines display?

The Videotex seemed like the answer to my problems, but I need more than 32 characters to log on to the system I use.

Eric Lutz
Columbia PA

When you buy a computer, you get what you pay for. The hardware to produce 32 characters is cheaper than that to produce 64. While it's quite possible that some hobbyist will design a circuit to do the conversion you suggest, it hasn't happened yet. Also, I wouldn't buy equipment on the presumption that you can easily redesign it.

As for logging onto a computer, the number of characters displayed on the screen is usually immaterial. The software-terminal program used with the computer should "wrap around" at the end of 32 characters onto the next line (even though you haven't hit the carriage-return key yet). The length of the line you send is entirely determined by when you type a carriage return (after 50, 75, or any number characters).

I wouldn't be especially concerned about a 32-character display given the price/performance ratio of the machine. . . . **Steve**

Comparing Frequency

Dear Steve,

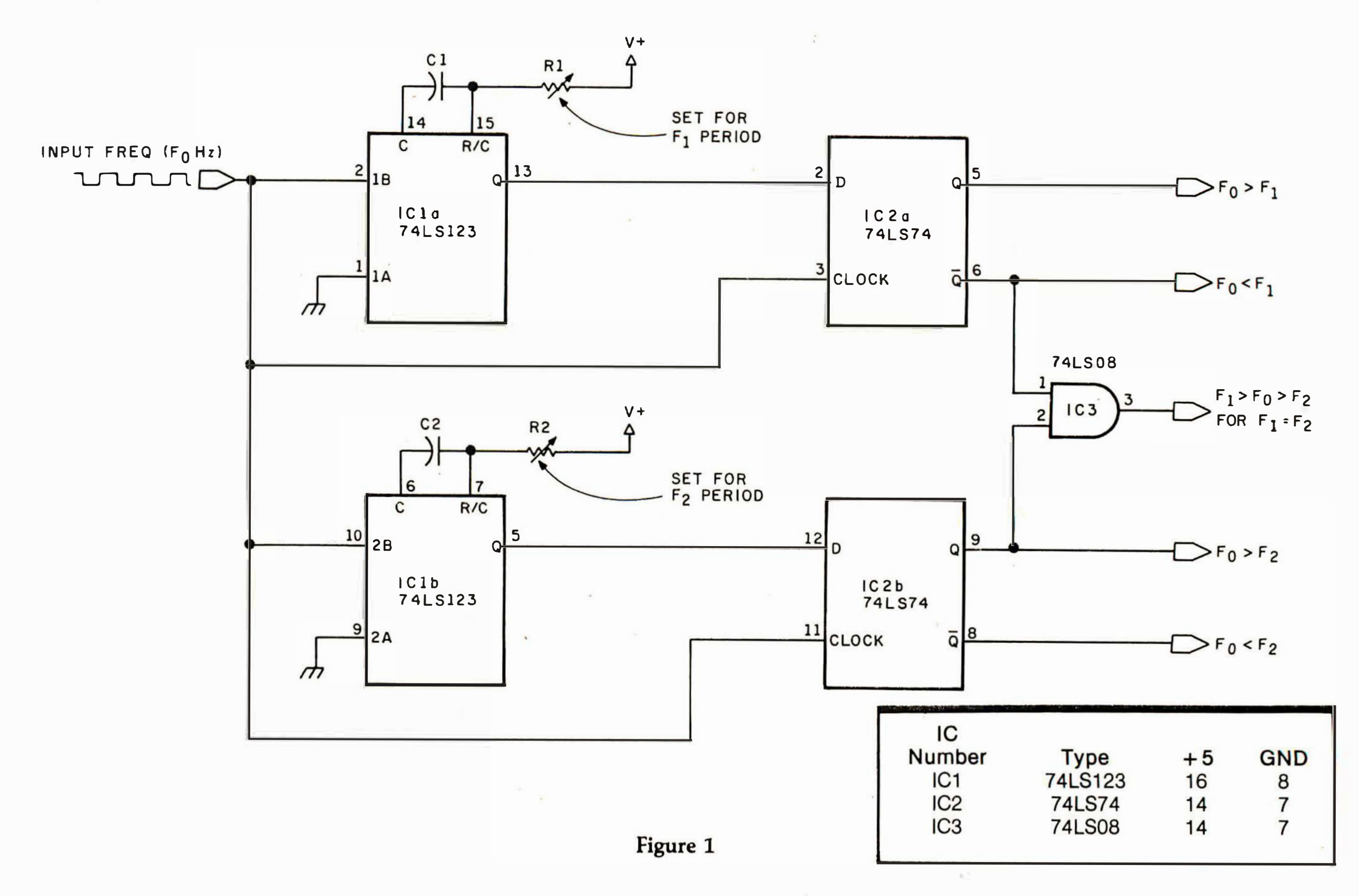
I am looking for a circuit that compares two input signals and detects which has the greater frequency. The project I am building has a +5 V supply, so it would be handy to use TTL (transistor-transistor logic). Are there single integrated circuits to perform this function?

Marvin Green
Tualatin OR

There are various ways to compare frequencies. The comparison can be either analog or digital. One analog method is to use frequency-to-voltage converters and simple "window" comparators. (This technique is reliable only at lower frequencies.)

Since you mentioned +5 V, you're probably more interested in a digital-frequency comparator. Generally this is accomplished by comparing the phases of the two signals. An integrated circuit specifically designed for this purpose is the Motorola MC4044 Phase Comparator. (Determining A>B or B>A requires additional circuitry.)

*If you know the ranges of the frequencies that you wish to compare, often it is easier to compare one unknown to some preset limits. (See figure 1.) Two retriggerable one-shots have their periods set for the upper limit (F1) and lower limit (F2) of the capture range. When the unknown frequency (F0) is applied, it is gated through the remaining circuitry to provide logic outputs such as F0>F1, F0>F2, F0<F1, or F0<F2. ...***Steve**■

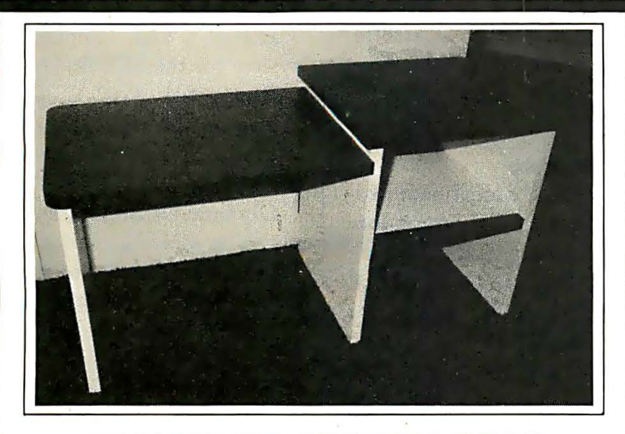


IC Number	Type	+5	GND
IC1	74LS123	16	8
IC2	74LS74	14	7
IC3	74LS08	14	7

Figure 1

Circle 240 on inquiry card.





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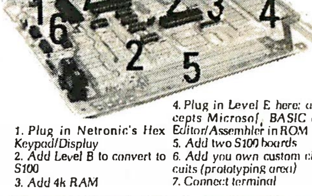




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6. Add you own custom circuits (prototyping area)
7. Connect terminal

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Software Received

This is a list of software packages that have been received by BYTE Publications during the past month. The list is correct to the best of our knowledge, but it is not meant to be a full description of the product or the forms in which the product is available. In particular, some packages may be sold for several machines or in both cassette and floppy-disk format; the product listed here is the version received by BYTE Publications.

This is an all-inclusive list that makes no comment on the quality or usefulness of the software listed. We regret that we cannot review every software package we receive. Instead, this list is meant to be a monthly acknowledgment of these packages and the companies that sent them. All software received is considered to be on loan to BYTE and is returned to the manufacturer after a set period of time. Companies sending software packages should be sure to include the list price of the packages and (where appropriate) the alternate forms in which they are available.

Apple

Address Book, name and address file and telephone dialer for the Apple II. Floppy disk, $49.95. Muse Software Company, 330 N Charles St, Baltimore MD 21201.

Data Fixer, disk software-repair utility for the Apple II. Floppy disk, $29.95. Image Computer Products, 615 Academy Dr, Northbrook IL 60062.

Data Plot, on-screen data-graphing program for the Apple II. Floppy disk, $59.95. Muse Software Company, (see above).

Invasion Force, graphics game for the Apple II. Cassette, $19.95. Compu-Things, 708 Broadway, Chelsea MA 02150.

Monitor Extender, machine-language utility for the Apple II. Cassette, $19.95. Image Computer Products (see above).

Spelling, three educational games for the Apple II. Floppy disk, $21.95. Software by Witzel, POB 2123, Littleton CO 80161.

Super Bar and Wine Guide, wine selection guide and bar recipe program for the Apple II. Floppy disk, $24.95. Cine-Aero Productions, 1821 N Frederic St, Burbank CA 91505.

Super Text Form Letter Module, add-on module to Super Text II word-processing package for the Apple II. Floppy disk, $100. Muse Software Company (see above).

Super Text II, word processor for the Apple II. Floppy disk, $150. Muse Software Company (see above).

Atari

Shuttle Ascent Simulation, space-shuttle simulation for the Atari 800. Cassette, $9.95. Starbound Software, POB 214, Cocoa Beach FL 32931.

Commodore

Addition, educational program for the Commodore PET. Cassette, $20. Teaching Tools, POB 12679, Research Triangle Park NC 27709.

Create-A-Base, data-base management program for the Commodore CBM. Floppy disk, $360. Micro Computer Industries Ltd, 1520 E Mulberry, Fort Collins CO 80524.

Subtraction, educational program for the Commodore PET. Cassette, $20. Teaching Tools (see above).

Exidy

Toolkit, screen editor and enhancements for the Exidy Sorcerer. Cassette, $69.95. North American Software, POB 1173 Station B, Downsview, Ontario, M3H 5V6, Canada.

Sword, word processor for the Exidy Sorcerer. Cassette, $34.95. North American Software (see above).

Super Graphic Scratch Pad Version 2.2, graphics utilities for the Exidy Sorcerer. Cassette, $24.95. North American Software (see above).

Radio Shack

Aviation, aviation-calculation package for the TRS-80 Pocket Computer. Cassette, $24.95. Radio Shack, 1 Tandy Ctr, Fort Worth TX 76102.

Cheaptalk, voice-output routines for the TRS-80 Model I. Cassette, $19.95. Alan Saville, POB 5190, San Diego CA 92105.

Income Property Analysis System, business-analysis program for the TRS-80 Model I or III. Floppy disk, $225. Advanced Business Microsystems, 5801 Marvin D Love Fwy, #103, Dallas TX 75237.

LDOS, disk operating system for the TRS-80 Model I. Floppy disk, $149. Galactic Software Ltd, 11520 N Port Washington Rd, Mequon WI 53092.

Olympic Decathlon, multiplayer graphics game for the TRS-80 Model I. Floppy disk, $24.95. Microsoft Consumer Products, 400 108th Ave NE, Suite 200, Bellevue WA 98004.

RSM Patch, modification package to Small Systems Software's RSM for the TRS-80 Model III. Cassette, $9.95. Remarkable Software, POB 1192, Muskegon MI 49443.

SECS, full-screen editor for the TRS-80 Color Computer. Cassette, $29.95. Datasoft Inc, 16600 Schoenborn St, Sepulveda CA 91343.

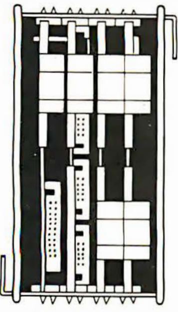
SIGMON, machine-language monitor for the TRS-80 Color Computer. Cassette, $29.95. Datasoft Inc (see above).■

Circle 243 on inquiry card.

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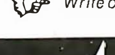
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BASIC, A Hands-On Method, Second Edition, Herbert D Peckham. New York: McGraw-Hill, 1981; 17.5 by 23.5 cm, 306 pages, softcover, ISBN 0-07-049160-7, $12.95.

BASIC-Pack Statistics Programs for Small Computers, Dennie Van Tassel. Englewood Cliffs NJ: Prentice-Hall, 1981; 21 by 28 cm, 230 pages, softcover, ISBN 0-13-066381-6, $16.95.

Basically Speaking, A Guide to BASIC Programming for the Interact Computer, Micro Video Corporation. Ann Arbor MI: Micro Video Corporation, POB 7357, 1980; 23 by 28 cm, 201 pages, softcover, ISBN-none, $14.95.

Data Structures Using Pascal, Aaron M Tenenbaum and Moshe J Augenstein. Englewood Cliffs NJ: Prentice-Hall, 1981; 18.5 by 24.5 cm, 545 pages, hardcover, ISBN 0-13-196501-8, $23.95.

The 8085 Microprocessor, Fundamentals and Applications (Hands-On), Howard Boyet. New York: MTI Publications, 1980; 18 by 25.5 cm, 420 pages, softcover, ISBN-none, $17.95.

First Course in Data Processing with BASIC, J Daniel Couger and Fred McFadden. Somerset NJ: John Wiley & Sons, 1981; 21.5 by 28 cm, 443 pages, softcover, ISBN 0-471-08046-2, $17.95.

First Course in Data Processing with BASIC, COBOL, FORTRAN, and RPG, J Daniel Couger and Fred McFadden. Somerset NJ: John Wiley & Sons, 1981; 21.5 by 28 cm, 532 pages, softcover, ISBN 0-471-05581-6, $20.95.

Fundamentals of Programming in BASIC, Robert C Nickerson. Cambridge MA: Winthrop Publishers, 1981; 17.5 by 23.5 cm, 400 pages, softcover, ISBN 8-87626-305-8, $12.95.

Introduction to Computer Operations, Second Edition, W M Fuori; A D'Arco; and L Orilia. Englewood Cliffs NJ: Prentice-Hall, 1981; 18.5 by 24.5 cm, 620 pages, hardcover, ISBN 0-13-480392-2, $19.

Introduction to Computer Data Processing, Third Edition, Wilson T Price. New York: Holt, Rinehart and Winston, 1981; 19 by 24 cm, 577 pages, hardcover, ISBN 0-03-056728-9, $18.95.

Invitation to Pascal, Harry Katzan Jr. Princeton NJ: Petrocelli Books, 1981; 16.5 by 24 cm, 233 pages, hardcover, ISBN 089433-103-5, $17.50.

MA-2 Microcomputer Applications, Volume 1, Howard Boyet and Ron Katz. New York: MTI Publications, 1979; 15.5 by 23 cm, 461 pages, softcover, ISBN 0-89704-026-0, $16.

MA-2 Microcomputer Applications, Volume 2, same as above, 290 pages, ISBN 0-89704-027-9, $9.

Microprocessor System Debugging, Noordin Ghani and Edward Farrell. Somerset NJ: John Wiley & Sons, 1980; 18.5 by 28.5 cm, 143 pages, softcover, ISBN 0-471-27860-2, $43.50.

Microprogrammed Control and Reliable Design of Small Computers, George D Kraft and Wing N Toy. Englewood Cliffs NJ: Prentice-Hall, 1981; 16 by 24 cm, 428 pages, hardcover, ISBN 0-13-581140-6, $21.95.

The Pascal Handbook, Jacques Tiberghien. Berkeley CA: Sybex, 1981; 18 by 23 cm, 500 pages, softcover, ISBN 0-89588-053-9, $14.95.

Programming with FORTRAN/WATFOR/ WATFIV, David T Basso and Ronald D Schwartz. Cambridge MA: Winthrop Publishers, 1981; 17.5 by 23.5 cm, 407 pages, softcover, ISBN 0- 87626-638-3, $12.95.

Systems Analysis and Management: Structure, Strategy and Design, Donald V Steward. Princeton NJ: Petrocelli Books, 1981; 16.5 by 24 cm, 287 pages, hardcover, ISBN 0-89433-106-X, $25.

TRS-80 Assembly Language, Hubert S Howe Jr. Englewood Cliffs NJ: Prentice-Hall, 1981; 18.5 by 24.5 cm, 186 pages, hardcover, ISBN 0-13-931139-4, $15.95.

Using Microprocessors and Microcomputers: The 6800 Family, J D Greenfield and W C Wray. Somerset NJ: John Wiley & Sons, 1981; 19.5 by 24.5 cm, 460 pages, hardcover, ISBN 0-471-02727-8, $22.95.■

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Dr Edward R Fisher, associate dean for research and graduate programs at the College of Engineering, assisted Mr Simkovitz with the patent process. A US patent is pending in Wayne State University's name. The two are now searching for a manufacturer that will help develop and market the LVTS. For more information, contact Dr Fisher, (313) 577-3861, or Dan Simkovitz, (313) 577-3902, at Wayne State University, Detroit MI 48202.■

Startrek 4.0 and Startrek 3.5

Scott Mitchell, 346 S Taylor St, Manchester NH 03103

Startrek 3.5 is the descendant of Lance Micklus's Startrek 3.0. It has been revised five times and is thoroughly debugged. It is the most widely distributed Startrek game. At first I thought it was unfair to compare Startrek 4.0 by Jeff Hamilton with Startrek 3.5, but after playing version 4.0, I found features in it that I liked, and many that BYTE readers might prefer.

Startrek 3.5 is a menu-driven program. After each sequence of events, you are returned to a list that has eleven command numbers and one invisible command. From this list, you pick and choose commands as if it were a menu. Commands include control of phasers, photon torpedoes, impulse and warp drives, long- and short-range sensor scans, and alert status. You can display the ship's current status, call up damage control to see what is or isn't functioning, call for repairs, or have the science computer tell you what objects are in your quadrant. The ship's computer command takes you into a subsystem that scans its data base for data on Klingon warships, starbases, class F stars, planets, unexplored areas, etc. The computer obtains this information each

At a Glance

Name Startrek 4.0	**Name** Startrek 3.5
Type Game	**Type** Game
Author Jeff Hamilton	**Author** Lance Micklus
Manufacturer The Programmers Guild POB 66 Peterborough NH 03458	**Manufacturer** Adventure International POB 3435 Longwood FL 32750
Price $14.95 tape, $19.95 disk	**Price** $14.95 tape, $19.95 disk
Format Cassette or 5-inch floppy disk	**Format** Cassette or 5-inch floppy disk
Language BASIC	**Language** BASIC
Computer TRS-80 Model I	**Computer** TRS-80 Model I
Documentation Two pages, 11.5 by 18 cm (4½ by 7 inches)	**Documentation** Thirteen-page pamphlet, 6 by 15.5 cm (2½ by 6 inches)
Audience All space-war game fans	**Audience** All space-war game fans
Challenge Very good	**Challenge** Excellent

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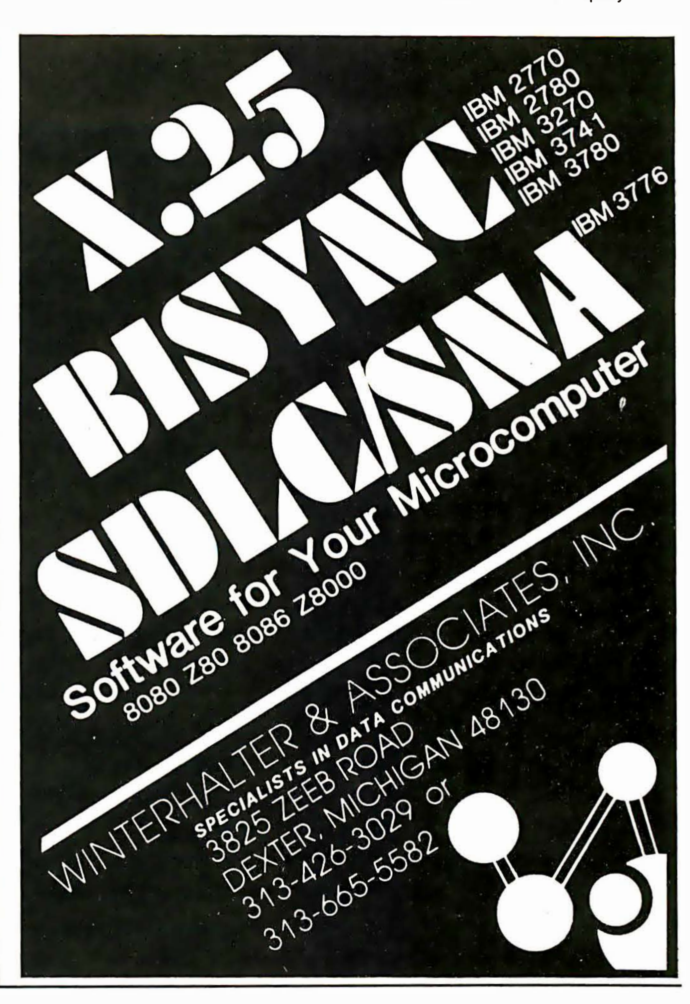
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time you request a sensor scan. The invisible command saves the game on disk or cassette.

Startrek 4.0 is not a menu-driven game; instead it runs in real time. To compare the two, let's say you were battling a Klingon warship and you fired your photon torpedoes and missed. The Klingon fired back and knocked out your science computer. At this point, 3.5 returns to the menu and waits for you to enter your next move. On the other hand, in version 4.0, you must think and act quickly because situations occur as in real-time events. For example, a Klingon can wander into your quadrant, spot and fire at you, and leave you dangling in space while you slipped out for a snack. Ship repairs also go on in real time. In general, Jeff Hamilton's Startrek 4.0 has the same commands as Startrek 3.5, but they are displayed in a small window on your control console as you enter them.

Startrek 3.5 has extensive and reasonably quick graphics. Sounds have been added to the game, but they are kept simple so as not to become tiring after many hours of play. Startrek 4.0 doesn't have sound and uses rather simple graphics. The screen accurately demonstrates what is happening, and it shakes wildly when you are hit.

The objective of 4.0 is to destroy all the Klingons within thirty-two stardates, while stopping at a starbase only twice. The objective of 3.5 is to destroy twenty Klingons by a certain stardate, but the game does not end there. You must also explore and collect as much data as you can about an entire region, and you must locate and orbit all class M planets. As you're doing that, you must cope with pulsars, black holes, and, of course, the crafty Klingons. When you have destroyed twenty Klingons and feel you have collected enough data, you dock at a starbase, where Starfleet Command rates your performance on a scale of 1 to 100%.

Startrek 3.5 has a three-dimensional universe (8 by 8 by 3) with 192 quadrants; a quadrant has 64 (8 by 8) sectors. Startrek 4.0 has a two-dimensional universe (8 by 8) with 64 quadrants. Again, each quadrant has 64 (8 by 8) sectors.

In Startrek 4.0, the computer can be used to help you figure out the exact coordinates to fire photon torpedoes or to navigate the ship. This helps your accuracy when you first start playing the game. Klingon warships using a cloaking device that makes them seem invisible are an extra problem in version 4.0, because they are immune to the photon torpedoes when in this state. In 4.0, but not in 3.5, if a star is in your path, you must navigate around it. In version 3.5, you must be true to your Starfleet orders, and never destroy a planet, star, or starbase, or the game ends immediately. The Klingons can maneuver out of the way of photon torpedoes and phaser fire.

Conclusions

While Startrek 3.5 is my personal favorite, Startrek 4.0 has an interesting angle to it. To some, the real-time aspect of 4.0 may make all the difference, but, all in all, both games are smooth-running and well debugged.■

The BDS C Compiler

Christopher Kern, 201 I St SW, Apt 839
Washington DC 20024

The ubiquitous Pascal compiler has joined the ubiquitous BASIC interpreter as a staple of the microcomputer programming environment, bringing with it the concepts of hierarchical program design, orderly program development, and legibility that generally fall together under the heading "structured programming."

But for those who are not ideologically committed to the proposition that Pascal is the most congenial programming language—and who have access to an 8080-based computer and the CP/M operating system—I would like to suggest an alternative: a language created at Bell Laboratories, named, with characteristic concision, C. C provides the same structured programming approach as Pascal, but it has a cleaner and crisper syntax, one that is both closer to the ultimate machine language of the computer and, paradoxically, somewhat easier to become familiar with than Pascal.

My recommendation is largely a product of my experience with one of the best and least expensive programming language packages I have come across: the C compiler developed by BD Software (by Leor Zolman of Cambridge, Massachusetts). I have been using the BDS C compiler for over a year, and I think many hobbyists who aren't already using a modern, high-level language could easily switch to C from their BASIC interpreter. C, like BASIC, can be learned quickly, but it has resources that BASIC, even in its ingeniously extended forms, can't match. And while the BDS C compiler does not provide as convenient a programming environment as BASIC—no compiled language really can—it comes about as close as possible to eliminating the worst annoyance of many compilers running on microcomputer systems: the long wait between idea and execution as the compiler cranks out an assembly-language file that must itself be compiled (run through an assembler) before the object program can be tested.

The operation of the compiler is relatively straightforward and quite fast. The command "CC1 filename.C" reads in the source program (which has been prepared using the host system's editing facilities and saved as a file on disk), parses it, and leaves the resultant intermediate file in memory. As CC1 goes out of business, it calls in another program, CC2, as an overlay (ie: it takes the place of the previous program). CC2 is the code generator: it saves the C machine-code program on disk in a special relocatable format. The relocatable machine-code program is turned into executable, absolute machine code by the linker, CLINK, which also merges the user's program with previously compiled program files (such as the standard C function library) if necessary. The entire source file is read into memory before compilation begins, but because it is possible to link separately compiled modules together, the available memory space of the computer does not limit source-program size. If the source code is too long to fit into the available memory at

At a Glance

Name
BDS C compiler

Type
8080 compiler

Distributor
Lifeboat Associates
1651 Third Ave
New York NY 10028

Price
Complete package, $145; documentation only, $25

Format
Available for all CP/M systems

Computer
Any 8080-based computer running Digital Research's CP/M operating system (programs compiled by the BDS C compiler can be tailored to run on any 8080-family computer)

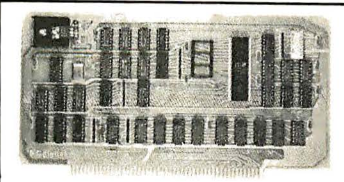
Documentation
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Audience
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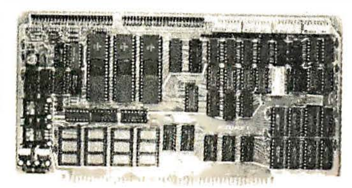
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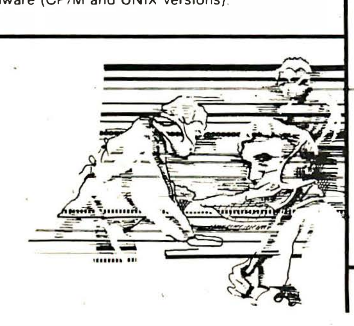
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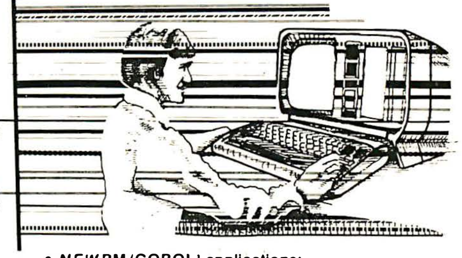
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one time, it can simply be divided up and compiled in pieces. The use of a separate linker also makes it possible to create libraries of compiled functions (such as the C standard library, which supplies a number of basic input/output and utility functions in every system that supports the C language) that can be used in the future as, essentially, part of the language itself.

The manual states that the parser (CC1) operates at about twenty lines of source code per second and that the code generator (CC2) runs at about seventy lines of source per second. In practice—at least on floppy-disk-based systems—the main limitation on compilation speed is the speed of disk input and output. On very long programs, there may be a wait of perhaps a minute while CC1 crunches away. Obviously this can be shortened considerably by compiling only the part of the program that is being worked on and linking it with other, previously compiled, routines. Even with relatively long programs that are compiled as a unit, however, I did not find the delay in compilation to be objectionably long.

For most users, the speed at which a compiled program runs, not the length of time required to compile it, is what really matters. I am reluctant to express this in terms of a benchmark, since the proposed benchmarks I have seen (1) require assumptions about the type of program that will be compiled that cannot hold from one user to the next; (2) can be properly compared only between systems that have both the same processor throughput and the

A Comparison of C and Pascal

C programs and Pascal programs look quite a bit alike. They should—the two languages have a lot in common, including sets of similar primitive operations that make direct Pascal-to-C or C-to-Pascal translation feasible. Yet enough differences exist to give the two languages a distinctly different "feel."

The most visible difference is block structure; C programs do not have the true block structure found in Pascal programs. A C program is a collection of separate functions; thus one function cannot be nested within another and called as a separate entity. C functions may contain blocks of code that are either executed completely or not at all, but they are not named as functions themselves, and they must be included in-line as part of the normal program flow within the function.

C uses only functions, where Pascal distinguishes between functions and procedures. In practice, the only real difference is that any C function can return a value to its calling routine. This is but one example of C's relaxed programming philosophy. Other examples include the ability to assign freely between integers and characters, and between pointers and unsigned integers, the latter providing virtually unlimited opportunity to perform address arithmetic within the host system's available memory space. There are times when this flexibility is very convenient, but there is a price: the compiler won't prevent a foolish move if the programmer insists on it. Whereas Pascal takes a very rigid, protective, and rather mathematical attitude toward program construction, C allows the programmer a certain amount of freedom. This makes sense: Pascal was designed as a teaching language, and C is a production programming language that allows the programmer to do things that he may want to do, at the expense of some conceptual niceties.

Both C and Pascal allow parameters to be passed to subroutines by value and by reference. This means that the called subroutine can receive either its own local copy of a parameter (which it can alter at will without changing the value of the variable as far as the calling routine is concerned), or a reference to the calling routine's variable (which can be subsequently altered by the subroutine that has been called).

Each language also provides pointers—variables that point to memory locations, such as the beginnings of arrays. In Pascal, pointers tend to be used sparingly, while in C they are much more common. Here again, C is unwilling to protect the programmer from himself. Pointers are risky. If they are misused, they can point somewhere entirely unexpected and clobber an innocent piece of unrelated code with predictably disastrous results. They can, however, make for extremely efficient programs, and C encourages their use.

C has been described as a relatively low-level language. It generally operates on the same primitive data objects as the computer itself, and it does not provide certain composite operations. For example, a string in C is a series of characters beginning at a given memory location, not a discrete entity that can be passed or assigned as a unit. Explicit functions are used to provide more sophisticated facilities for manipulating data objects, as well as for input and output. The more common primitive operations are provided in the C standard function library. Others must be written by the programmer.

One of C's most distinctive features is its unusual—and unusually concise—set of operators. C has multiple assignment operators that lead to expressions of the form x += 1 or y >>= 4. These mean, respectively, "let x equal x plus one" and "let y equal y logically shifted right 4 bits." Another unique C concision is the ? : (if... then) operator. It is used in expressions of the form y = x>0 ? 1 : 0. This means "if x is greater than 0 let y=1; otherwise, let y=0."

BASIC exists in thousands of dialects. The same diffusion seems to be taking place—to a lesser extent, fortunately—with Pascal. Thus far, not many compilers operate on variations of C, so true portability between computers still exists. I know of three microcomputer C compilers: the BDS compiler (which implements a very complete subset of the language); one for a considerably more restricted (and slightly archaic) subset of C that was published, in C source code, in the May 1980 issue of Dr Dobb's Journal of Computer Calisthenics and Orthodontia *(this compiler is available from Walt Bilofsky, 14478 Glorietta Dr, Sherman Oaks CA 91423, in CP/M and Heath HDOS formats); and Whitesmiths' C Compiler, which provides the full C language for various 8080-family and DEC LSI-11 systems (Whitesmiths Ltd, POB 1132, Ansonia Sta, New York NY 10023). An excellent C-like interpreter is available from tiny-c associates, POB 269, Holmdel NJ 07733 (see my review of tiny-c: "A User's Look at tiny-c," December 1979 BYTE, page 196). A tiny-c compiler is also available.*

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same disk-access speed, and (3) are of dubious value when used to compare different programming languages because it is unlikely that the benchmark programs will be of equivalent efficiency in all languages.

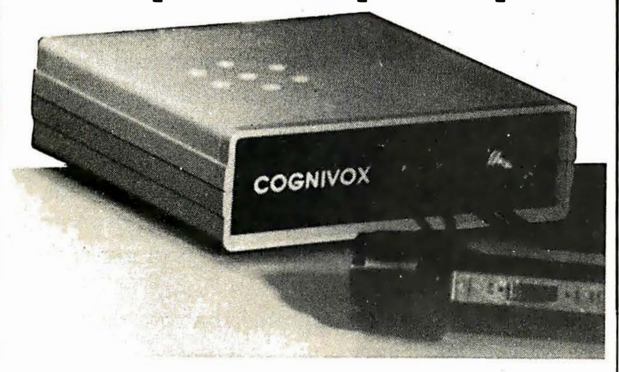
Having said all that, I will venture the opinion (acknowledging that it may be even more misleading than a benchmark program) that programs compiled on the BDS compiler run very fast indeed. Not as fast as those coded in assembler, obviously, but much faster than any BASIC interpreter, considerably faster than any pseudo-code Pascal system (a technique that amounts to semi-compilation, with object code being generated for a "pseudo-machine" that is emulated by the host computer), and *about as fast* as those created by any microcomputer compiler I have seen. I have used BDS C to compile a rudimentary LISP interpreter, and while it's no match for a machine-coded LISP, the project demonstrated to my satisfaction that the BDS compiler is suitable for system-programming purposes.

BDS C is a true subset of the standard C language. Very little is left out. The most serious omissions are the lack of static variables and initializers. Several library functions are supplied to remedy the latter, although initialization remains somewhat more awkward than in standard C. Also absent are floating-point real numbers and long (32-bit) integers. A series of subroutines to perform floating-point conversions and arithmetic is supplied with the package, but this is not as convenient a way to provide real numbers as building them into the language the compiler accepts directly.

A considerable amount of work has been done to relieve the programmer of some of the more tedious aspects of the CP/M operating system. Library functions permit the use of the standard CP/M carriage-return/line-feed sequence to terminate a line or, at the user's option, the single newline character that is standard in other C programming environments. Buffered file routines are supplied as part of the standard library, which permits the programmer to write data to disk a character at a time instead of in blocks of 128 characters, as required by CP/M. Dynamic storage allocation and deallocation are also provided, so the user can create and dismantle complex data structures at run-time, and therefore reuse the memory area allocated to them (even though CP/M itself contains no allocation mechanism).

It's a shame the BDS compiler doesn't go one step further and provide redirected input and output; this would have permitted the user to write a program using a single I/O stream and then specify at run-time whether the program was to communicate with the console, a modem, a disk file, etc. Some high-level language compilers provide a debugging option that allows the user to trace program execution and print out variable values. Alas, BDS C is not one of them. Short of that, the best debugging tool I

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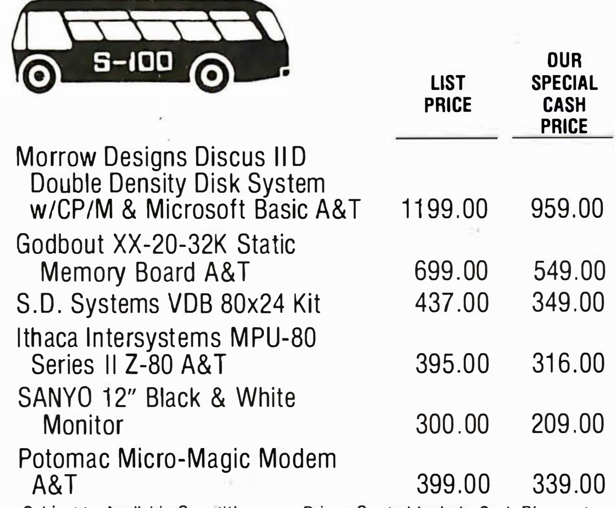
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have found comes right out of the C standard library. It is the function "printf", which allows various data objects to be printed in appropriate formats and number bases while the program is being run.

The compiler accepts a number of optional directives that allow the user to:

- Place the generated code in any memory location (including read-only memory, as long as some programmable memory will be available somewhere in the target system)
- Optimize the object code for speed (which increases the amount of code generated) or for size (which slows the object program down a bit), and to control the way the compiler allocates space
- Save an intermediate file on disk between the two compiler phases
- Display the source text on the user's console during compilation

The linker also supports a number of useful options, including several that permit the programmer to create overlay segments that use the same data elements. This feature is not commonly available in microcomputer compilers for high-level languages.

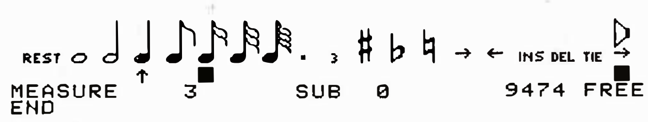
The assembly-language source code for the run-time package is also supplied (the run-time routines contain the interface to the CP/M operating system). This permits the user to create a customized run-time package that allows BDS C programs to run under other 8080 operating systems. Those who sell application programs will, no doubt, be happy to learn that there are no royalty requirements for programs that include the run-time package in either its original or customized form.

In addition to the compiler and the linker, the BDS C package contains a librarian program, CLIB (used to manipulate compiled function libraries), the C standard library along with some useful extensions for the microcomputer (and specifically the CP/M) environment, and a collection of sample programs that is of more than passing interest.

The precise sample programs that are delivered with any package may vary, but the copy of BDS C Version 1.4 that I received from Lifeboat Associates in New York contained a fairly sophisticated telecommunications program for connecting a microcomputer system through a modem to another microcomputer (or a time-sharing system), several impressive games (some requiring a cursor-addressable video terminal), and several utility programs, including two that permit the compiler to be used from terminals that generate uppercase characters only. The package also includes a lucidly written manual for the compiler and a copy of the outstanding C language manual, *The C Programming Language*, by Brian W Kernighan and Dennis M Ritchie. ■

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—Kirkland, Washington

I would like to tell you that after having used the system ONLY ONE DAY, that I am absolutely delighted with it. In addition, I purchased the three boards although I ALREADY own Mountain Hardware's music system. Now that I have seen and own your system, I am putting my "old" one up for sale. I think that your software makes it far easier to enter music, and that the software routines allow for far greater flexibility. Again, I extend my compliments to you. As I said, I have owned another music system, and consider myself therefore, qualified to make a judgement between the use of the two. Yours is the clear choice!

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Book Reviews

Musical Applications of Microprocessors

by Hal Chamberlin
Hayden Book Company, Inc
Rochelle Park, NJ
1980, 661 pages, hardcover $24.95

Reviewed by
Dick Moberg
404 S Quince St
Philadelphia PA 19147

This book is the culmination of many years of experimentation by one of the leaders in the field of computer music for small systems. Its depth of coverage and usefulness are unsurpassed by any other single publication.

A review cannot start without first looking at the book's author. Hal Chamberlin has been involved with microcomputers since their origin. His newsletter, *The Computer Hobbyist*, pioneered construction articles on tape, disk, and graphic interfaces long before there were any books or major publications on the subject. Combining his music and computer talents eventually led him to form a company, Micro Technology Unlimited, and to receive an award for his contributions at the 1979 Personal Computer Arts Festival. He is an avid writer for personal-computer magazines. His clear and often humorous style is prevalent throughout his book.

Before we look at the contents, let's discuss the book's intended audience. Being a long-time computer hobbyist with several years of childhood music lessons, I would target this book for the computer tinkerer or the musician with some syn-

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Book Review

thesizer knowledge. The non-musician will find the introductory parts on waveforms and music theory sufficient for understanding the rest of the book. The musician with no background in computing or electronics should have available some of the excellent paperback volumes now available on op (operational) amps, TTL (transistor-transistor logic) circuits, and microcomputers. But, even for the computer-musician novice, this is a book that is readily understandable.

Musical Applications of Microprocessors is divided into three sections: "Background," "Computer-Controlled Analog Synthesis," and "Digital Synthesis and Sound Modification."

Section I covers background material in music synthesis and microprocessors. The first chapter, "Music Synthesis Principles," starts with a discussion on the goals of music making, comparing conventional instruments with electronic-synthesis techniques. It emphasizes that with electronic synthesis, a musician is limited only by his imagination as to the accuracy, complexity, and variety of sounds that can be achieved with this medium. Next, the author discusses the relationship of the physical parameters of waveforms — frequency, amplitude, and harmonics — to the musical concepts of pitch, loudness, and timbre. The chapter ends with a history of electronic sound synthesis from the teleharmonium to the microprocessor.

Chapter 2 presents the terminology and techniques of sound modification. It starts with a section on tape-recording techniques (rearranging tape splices, speed transposition, etc) and then compares these to their electronic counterparts. Other electronic techniques such as

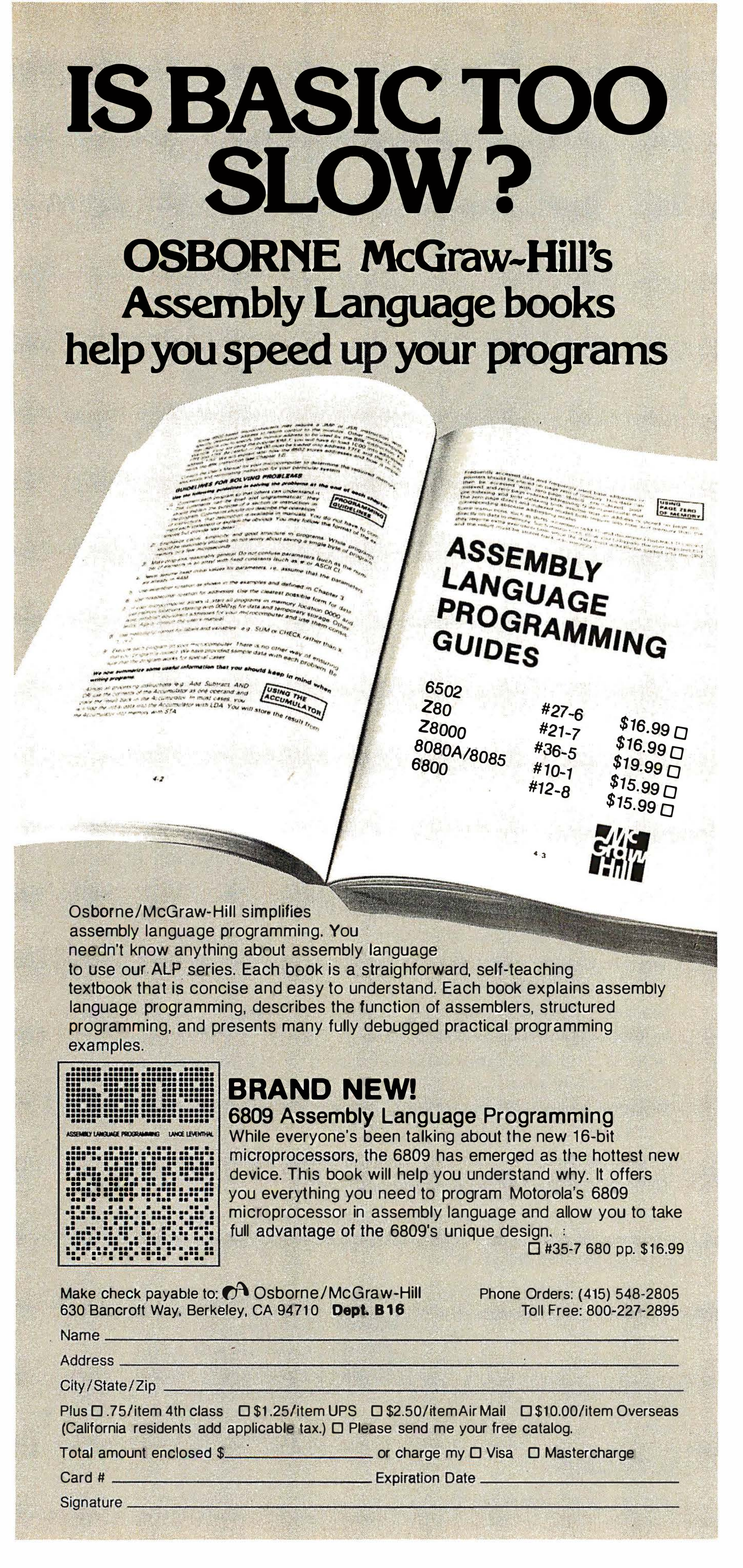
filtering, spectrum shifting, reverberation, and chorus synthesis are discussed. The chapter concludes with a discussion on analyzing natural sounds for subsequent modification.

The next chapter, on voltage-control methods, explains the conventional techniques of using voltage to control frequency, amplitude, and harmonics. Each of these techniques is later explained in regard to its implementation with analog and digital circuits or by using software programming. The modular nature of conventional synthesizers is also discussed.

Chapter 4 addresses waveform synthesis by the computer by digital-to-analog conversion and looks at the advantages and limitations of using this method. Music-programming systems and languages, including MUSIC V and Hal's NOTRAN (NOte TRANslation language), are briefly described.

The background section concludes with a chapter on microprocessors. There is an interesting comparison between the 8080, LSI-11, and 6502 microprocessors showing where each (and similar processors) should be used in the grand scheme of a music-synthesis system. The author claims that the 8-bit 8080/Z80 family are the optimal microprocessors for synthesizer control, the 16-bit LSI-11 for direct microprocessor synthesis of music, and the 8-bit 6502 for replacing dedicated logic. Although the choice of processor will vary from one designer to the next, this section gives the design criteria and the desired microprocessor parameters for each area of application.

The remaining two sections of the book offer technical how-to information regarding microcomputers in music synthesis. There's a discussion on the use of a



Book Review

microcomputer as a controller of standard or custom analog sound-synthesizing equipment, and how a computer can simulate the analog module's functions in software to provide direct music synthesis.

The first chapter of the computer-controller section explains circuit details of the three voltage-controlled synthesizer modules—voltage-controlled oscillator, voltage-controlled amplifier, and voltage-controlled filter. Component values are provided along with construction tips for building those modules.

The next chapter, on data-conversion techniques, starts with a tutorial on the terminology regarding the use of D/A (digital-to-analog) and A/D (analog-to-digital) converters. All circuits for the various conversion techniques are given, along with component values and available devices. One impressive circuit shows how to make a 128-channel microcomputer-controlled D/A converter for less than $50.

The remaining four chapters in this section deal with the "systems" aspects of a computer-controlled synthesizer. A chapter on signal routing shows how the computer and various switching devices can replace the ever-confusing patch cords on conventional analog synthesizers. Two chapters on input devices follow: one entirely on keyboard-input methods and one on other devices such as ribbon controllers, joysticks, and digitizers. The last chapter describes the role of computer-graphics displays as aids in computer music composition.

The last section of the book, on direct computer synthesis of music, gives details on digital sound generation and filtering techniques, and includes the techniques that the author

has pioneered through much of his previous writings. The section opens with a discussion of quality data-conversion techniques. Three chapters follow on digital sound-generation methods, including separate chapters on filtering and percussive sound generation. The chapter on digital tone-generation techniques includes the author's table-look-up method for generating precomputed waveforms and algorithms, and includes uses of Fourier techniques for "synthesis from scratch." The digital-filtering chapter gives techniques for reverberation and chorus effects.

Direct computer synthesis of music is usually not a real-time technique. But, as the author points out, these techniques are very useful for those designing real-time systems for live performances.

A fascinating chapter follows on the analysis of natural sounds for modification and resynthesis. Methods of three-dimensional spectral plotting for harmonic visualization are covered. Also mentioned are some advanced techniques for sound analysis, such as linear prediction, autocorrelation, and homomorphic analysis.

The last two chapters deal with digital hardware and music-synthesis software. The digital synthesis of music can be accomplished by using either hardware or specific software techniques, or a combination of the two. These chapters discuss the trade-offs of each method. Among other topics the hardware chapter presents circuits for digital multiplexed oscillators, Fourier-series tone generators, and hybrid voice modules. Some of the available music-synthesis boards for small computer systems are also analyzed.

The last chapter describes

Book Review

the hierarchy of music-software systems with examples from each level. Fixed-point-arithmetic routines for the 6502 processor are given, along with Fourier-series routines for waveform-table filling and much more. The chapter ends with a discussion of the high-level NOTRAN music-composition language.

In summary, this book is a milestone in microcomputer history. Its publication marks the progression — from novelty to serious instruments of expression — of musical applications of small computer systems. With little modification, the book could serve as a reference source on generalized data collection, signal processing, and process control using microcomputers.■

BYTE's Bits

Errata Sheets for Osborne Books

If you have been having trouble running some of the CBASIC programs in Osborne/McGraw-Hill business books, a simple request will bring quick relief in the form of errata sheets. The sheets should have been sent with every ordered copy of *Payroll with Cost Accounting, Accounts Payable and Accounts Receivable*, and *General Ledger*. If errata sheets weren't included in your book, contact Sean Dugan, Customer Relations, Osborne/McGraw-Hill, 630 Bancroft Way, Department B10, Berkeley CA 94710, (415) 548-2805.■

Clubs and Newsletters

Atari Users Group

The Bay Area Atari Users Group meets on the first Monday and on the third Tuesday of each month at 7 PM. The Monday-night meeting takes place at Foothill College, and the Tuesday-night meeting is at Interim Electronics, 447 S Bascom Ave, San Jose, California. The group publishes a newsletter. The dues for the group are $12 per year. The club currently has eight disks of public-domain software for sale at $5 per disk. The monthly meetings feature speakers discussing microcomputer uses and the Atari. Write to the Bay Area Atari Users Group, c/o Foothill College, 12345 El Monte Rd, Los Altos Hills CA 94022.

Just for LAUGHS

The Louisville Apple User Group—Hardware and Software (LAUGHS) has separate meetings for the business, software, and special-interest subgroups. A monthly newsletter is published. The subscription rate is $15 per year. For information, contact LAUGHS, c/o Pat Connelly, 3127 Kayelawn Dr, Louisville KY 40220.

Behavioral Sciences AIM-65 Users Group

Workers in the behavioral and biological sciences who are currently using or are interested in using the Rockwell AIM-65 are invited to participate in this group. Areas of study include hardware and software for experimental control, data acquisition, statistical analyses, and other applications. If you are interested, please write, outlining areas of interest and current or planned projects, to Dr J W Moore Jr, POB 539, Middle Tennessee State University, Murfreesboro TN 37132.

OSI Group In Northern California

The Ohio Scientific Users Group of Northern California has been formed. For details, write to Rod Freeland, c/o Public Interest Computer Services, POB 1061, Berkeley CA 94701; or call (415) 654-9880 after 1 PM.

68XX Users Group

This is a group for those hobbyists who have a strong interest in Motorola 68XX microprocessors. The group meets on the second Tuesday of each month in Santa Clara at American Microsystems Inc. Contact the 68XX Users Group at POB 18081, San Jose CA 95158.

Boston Group Promotes Artificial Intelligence

The Boston Subchapter of Robotics International of SME has been formed under the auspices of the Society of Manufacturing Engineers. The group has been developed to provide a forum for the exchange of information between engineers, scientists, industrial producers, and users of robotics technology.

For more information on the Boston chapter and the national group, contact Robotics International of SME, One SME Dr, POB 930, Dearborn MI 48128. ■

Event Queue

June 1981

June 6-9
Atlanta Small Computer Show, Atlanta Hilton, Atlanta GA. Producers of small computers, peripheral equipment, supplies, and services will be exhibiting at this show. Business owners, corporate and government executives, data processing managers, doctors, lawyers, and other professionals, are expected to attend. Obtain additional information from The Atlanta Small Computer Show, 4060 Janice Dr, Suite C-1, East Point GA 30344, (404) 767-9798.

June 7-19
Computer Camps, Northeast Louisiana University (NLU), Monroe LA. NLU is offering two one-week sessions for students in grades nine thru twelve. Beginners and advanced programmers are welcome. The cost is $125 per session for room, board, fees, and text materials. Contact Dr Paul Ohme, Department of Mathematics, NLU, Monroe LA 71209, (318) 342-2186.

June 9-11
Understanding and Using Computer Graphics, Chicago IL. This seminar will cover the latest technology on graphic systems. It will be headed by Carl Machover. Contact Bob Sanzo, Frost & Sullivan Inc, 106 Fulton St, New York NY 10038, (212) 233-1080.

June 14-18
The Second National Conference of the National Computer Graphics Association, Baltimore Convention Center, Baltimore MD. Computer graphics demonstrations and workshops will be held along with exhibits and seminars. Contact the National Computer Graphics Association Inc, 2033 M Street NW, Suite 330, Washington DC 20036, (202) 466-5895.

June 16-18
NEPCON East '81, New York Coliseum, New York NY. This exposition is aimed at engineers, prototype developers, production specialists and testing personnel. Technical programs will be presented. Contact Industrial & Scientific Conference Management Inc, 222 W Adams St, Chicago IL 60606, (312) 263-4866.

June 17-19
National Educational Computing Conference, North Texas State University, Denton TX. This conference will provide a forum for discussion between individuals, and institutions with interests in educational computing. Computer literacy, computer education for teachers, and computers in education are some of the topics to be covered. Contact Dr Jim Poirot, NECC-81, General Chairman, Computer Sciences Department, North Texas State University, Denton TX 76203.

June 21-26
Computer Workshops for Educators, Northeast Louisiana University (NLU), Monroe LA. This program will cover a wide variety of topics. Room, board, and tuition is $135. Contact Dr Paul Ohme, Department of Mathematics, NLU, Monroe LA 71209, (318) 342-2186.

June 22-23 and June 24-27
Digital Electronics for Automation and Instrumentation and Microcomputer Design Interfacing, Programming, and Application Using the Z80, 8080, and 8085, Virginia Polytechnic Institute and State University, Blacksburg VA. These two workshops allow participants to design and test concepts with the actual hardware. For more information, contact Dr Linda Leffel, CEC, Virginia Tech, Blacksburg VA 24061, (703) 961-5241.

June 23-25
Comdex/Spring '81, Madison Square Garden and New York Statler Hotel, New York NY. Contact the Interface Group, 160 Speen St, Framingham MA 01701, (800) 225-4620; in Massachusetts (617) 879-4502.

June 29-July 1
The Nineteenth Annual Meeting of the Association for Computational Linguistics, Stanford University, Stanford CA. Syntax, parsing, and sentence generation, computational semantics, discourse analysis and speech acts, speech analysis and synthesis, machine translation and machine-aided translation, and mathematical foundations of computational linguistics are some of the topics that will be discussed. Contact Don Walker, Artificial Intelligence Center, SRI International, Menlo Park CA 94025, (415) 326-6200, ext 3071.

July 1981

July 9-10 and July 20-21
Software Engineering, Denver CO and Seattle WA. Designed for systems analysts, designers, programmers, and managers, this seminar examines the latest developments in software engineer-

ing. For more information, contact Battelle, Seminar and Studies Program, 4000 NE 41st St, POB C-5395, Seattle WA 98105, (206) 525-3130.

July 29-31
The 1981 Microcomputer Show, Wembley Conference Centre, London, England. Seminars on microcomputer applications in business, production, and in education will be presented. Topics for conference sessions include hardware availability, software packages and development, automatic test equipment, robotics, and process control. Exhibits from major European and American manufacturers will be featured. Contact TMAC, 680 Beach St, Suite 428, San Francisco CA 94109, (800) 227-3477; in California (415) 474-3000.

August 1981

August 24-27
Software Design, Reliability, and Testing, Sheraton Motor Inn, Lexington MA. This four-day seminar is for engineers, programmers, and technical managers. It examines concepts and techniques for developing and testing reliable, cost-effective software. It also addresses management concerns and recommended policies. Tuition is $600, which includes course notes, luncheon, refreshments, and an evening reception. Contact the Institute for Advanced Professional Studies, One Gateway Ctr, Newton MA 02158, (617) 964-1412.

August 24-28
The Seventh International Joint Conference on Artificial Intelligence, University of British Columbia, Vancouver, British Columbia, Canada. This conference examines computer applications of medical diagnosis, computer-aided design, robotics, programmable automation, speech understanding, vision, and other related topics. Tutorial programs and artificial-intelligence exhibits will be presented. For more information, contact Louis G Robinson, American Association for Artificial Intelligence, Stanford University, POB 3036, Stanford CA 94305, (415) 495-8825.

August 25-28
Vector and Parallel Processors in Computational Science, Chester, England. This conference will concentrate on hardware, software, algorithms, applications, and case studies concerning vector and parallel processors. For information, contact Mrs S A Lowndes, Science Research Council, Daresbury Laboratory, Daresbury, Warrington, WA4 4AD, England.

August 26-29
The Fifth Annual National Small Computer Show, New York Coliseum, New York NY. There will be daily lectures, and a five-hour seminar will be presented daily for executives who need an introduction to the understanding, acquisition, and use of computers in business. The registration fee for the show is $10 per day. The seminar for executives is $200, which includes all materials and show registration. For information, contact the National Small Computer Show, 110 Charlotte Pl, Englewood Cliffs NJ 07632, (201) 569-8542.

August 28-30
Personal Computer Arts Festival '81 (PCAF '81), Philadelphia Civic Center, Philadelphia PA. This show will include technical sessions, demonstrations, and exhibits, as well as the annual computer-music concert and computer graphics film and video show. PCAF '81 is being held in conjunction with the Personal Computing '81 show. For complete details, contact the address below.

The PCAF '81 Committee invites persons interested in microcomputer-music and digital-sound synthesis, computer composition tools, signal processing, computer-generated visual art, and other computer-based creations, to talk, demonstrate, display, or perform at PCAF '81. To participate, send a half-page description of a topic or performance (include tapes, prints, or slides, if possible) before July 1 to PCAF '81, POB 1954, Philadelphia PA 19105.■

Book Reviews

TEX and METAFONT: New Directions in Typesetting

by Donald E Knuth
Digital Press,
Bedford, MA 1979
$12.00

Reviewed by
Richard Fritzson
25 Callodine Ave
Buffalo, NY 14226

TEX and METAFONT is primarily documentation for two programs that Donald E Knuth has written. TEX is a text-formatting program for preparing documents and METAFONT is a program for designing new fonts for digital typesetting devices (such as high-density raster-scan printers). The two manuals are preceded by a forty-page talk that Dr Knuth presented to the American Mathematical Society on the subject of mathematical typography.

Normally, program manuals are not very interesting, even to people who are using the program, and, unfortunately, most people are not yet using TEX or METAFONT. However, if you are interested in how a well-designed program can produce high-quality camera-ready text, if you are interested in mathematical methods for designing new type fonts, or if you are just interested in how a world-renowned computer scientist goes about designing, writing, and documenting his programs, read this book.

The introductory lecture, "Mathematical Typography," describes two aspects of the same subject: how to make it easy to compose mathematical papers of very high visual quality (ie: easy to read, beautiful to look at),

and how to use mathematics in the design of good-looking type fonts. It contains very brief introductions to both TEX and METAFONT, but, more interestingly, Dr Knuth describes some of the history of typesetting and typefont design and some of the history of his investigations into mathematical typesetting and font design, including some of the decisions he made while designing the two programs. His prose is comfortable and enjoyable. If you find it necessary to skip the more technical mathematics, you're skipping only about one page of Dr Knuth's lecture.

Judged by its manual, TEX is unlike any other text-formatting program. The care and thought that went into its design set a standard for programs of this kind, and programs in general, that few can meet. It uses a novel algorithm for splitting text into equal-length lines which considers the appearance of the entire paragraph in which the line appears, not just the line itself. It has extensive facilities for handling mathematical formulas in a manner that is easy for the typist but yields professional-looking output. (Naturally it supports proportionally spaced type fonts, multiple-column page formats, footnote references, and other features which are essential for full typesetting capability.) The manual is easy to read, and while it certainly makes you wish you had a copy of TEX to run on your own computer, you don't need it to enjoy reading the manual. (Dr Knuth says that he intends to publish the programs in a book, putting them in the public domain.)

As far as I know, METAFONT, the typeface-design program, is unique. It allows you to write programs, in a special METAFONT language, that specify the shapes of a family of characters — that is, it allows you to design your own type fonts. Currently though, only high-density raster-scan

Book Review

printers can print the new fonts, and these devices are still extremely expensive. Consequently, the microcomputer applications for a font-design program are limited. However, like the TEX manual, the METAFONT manual is both interesting and informative. It reads as though the author were standing at times in front of you lecturing and, at other times, behind you looking over your shoulder, helping. Even if you are just interested in the design of type fonts by Dr Knuth's analytic method, you will find this book useful. (The manual includes many exercises. While they are interesting to read, if you're not actually trying to learn to use TEX or METAFONT you may well want to skip them; I did.)

I used to think that only a hard-core, lost soul computer hacker could enjoy reading a manual for a program he might never use. This book has made me reconsider. ■

BYTE's Bugs

Correction

The name of the manufacturer of the wire-wrap prototyping board mentioned in "What's Inside Radio Shack's Color Computer?" (March 1981, BYTE, page 90) should have been Vector Electronic Company. We apologize for any confusion this may have caused. ■

Notice of Omission

Due to a processing error the Washington Computer Service ad which appeared on page 27 of the May Byte had no Reader Service Number.

For more information regarding their "no problem trial offer" circle 475 on the inquiry card in this issue.

BYTE's Bits

First Annual Undergraduate Paper Competition in Cryptology

Cryptologia, a magazine devoted to cryptology, has announced a contest for undergraduate students who have an interest in the study of encoding and decoding. A $300 award will be given to the student whose paper on any aspect of cryptology is judged the most valuable. Topics can include technical, historical, and literary subjects concerning cryptology.

Papers must be no more than twenty typewritten pages in length, double-spaced and referenced. Four copies must be submitted. Only original works that have never been published should be submitted. Authors must be enrolled in an undergraduate curriculum at the time of composition. All copies become the property of *Cryptologia* and the magazine assumes publication rights on all entries.

The papers will be judged by the editors of the magazine, and the winner will be announced on April 1, 1982, with publication of the winning paper in the July 1982 issue of *Cryptologia.* For information, contact *Cryptologia,* Albion College, Albion MI 49224. ■

An Easy-to-Use A/D Converter

Robert Daggit
1648 Hillview Rd
New Brighton MN 55112

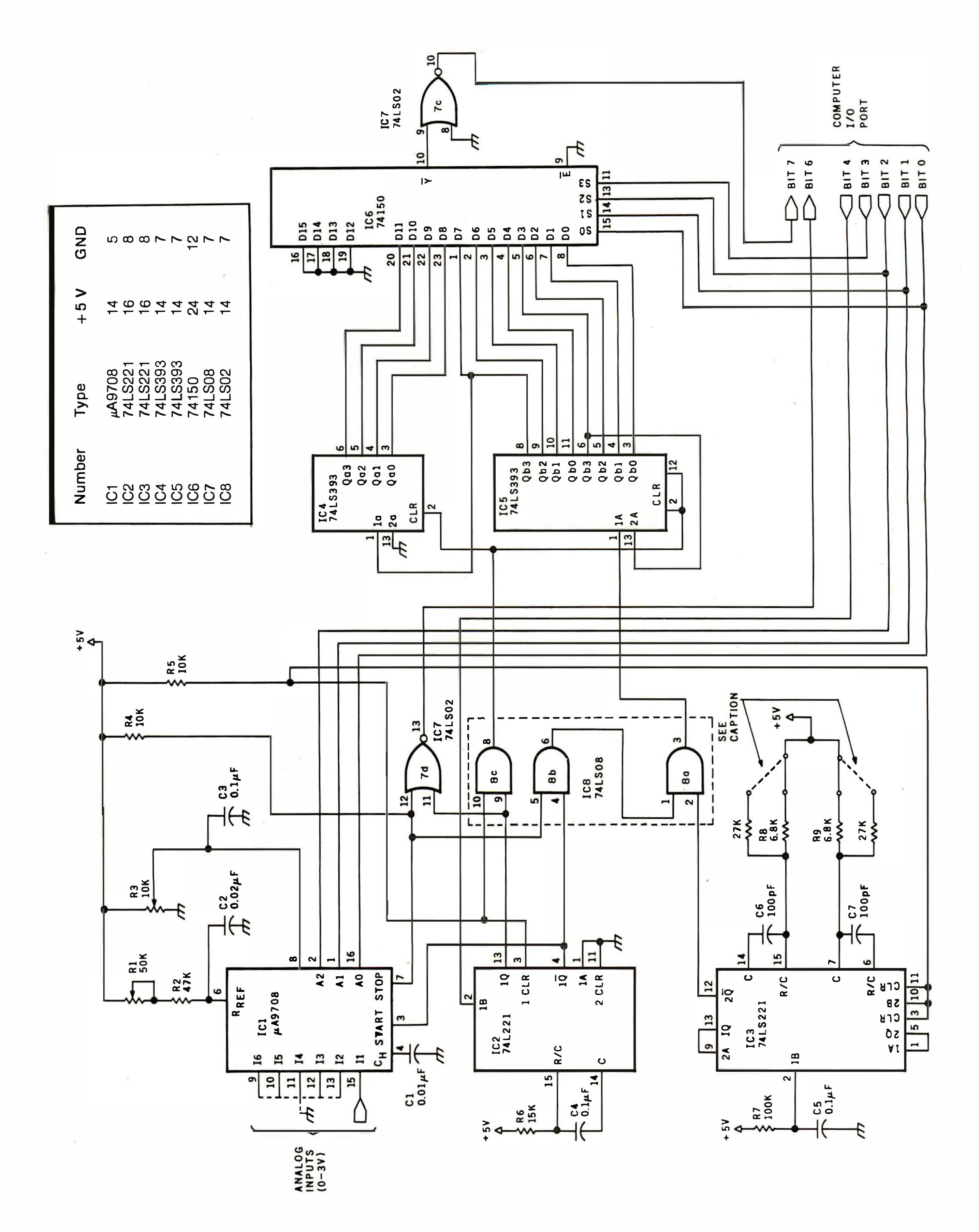
With the addition of an analog-to-digital converter and some simple sensors, a microcomputer can monitor analog voltages, read light levels, sense temperatures, or read the analog output from laboratory instruments. The six-channel A/D (analog-to-digital) converter that I will describe reads positive voltages from 0 to 3 V, with either 8 or 10 bits of accuracy. It interfaces to the computer through an 8-bit bidirectional peripheral port whose I/O (input/output) lines are individually programmable and latched when used as outputs.

About the Author
Robert Daggit is a Senior Research Technician at the Systems and Research Center of Honeywell Inc in Minneapolis. He is interested in the application of microprocessors to small, dedicated systems for laboratory use.

Once started, the converter operates asynchronously with respect to the computer and requires a minimum of code in the user's program. Conversion times are voltage-dependent, with an approximate range of 1 to 2 ms (milliseconds). A sample program segment and subroutine written in 6502 assembly language are included to illustrate the use of the converter.

Major components of the A/D converter unit, shown as a schematic diagram in figure 1, are a Fairchild Semiconductor μA9708 analog-to-digital-converter integrated circuit, a clock, a 12-bit counter, and a 16-bit output multiplexer. The μA9708 features an analog input multiplexer, controlled by address lines A0 thru A2, that selects one of eight input sources. Address 0 selects the internal zero voltage, and address 7 selects the internal reference voltage. Addresses 1 thru 6 select user inputs I1 thru I6, as shown in figure 1. Although the manufacturer rates the μA9708 at 8 bits of accuracy, it performs well at 10 bits of accuracy. A series of voltage readings taken at 0.1 V intervals from 0 to 3 V compared favorably with readings taken with a Fluke Model 8000A Digital Multimeter. Voltage differences ranged from 2 to 11 mV (millivolts). The greatest relative error, defined as the absolute value of the voltage difference divided by the multimeter reading, was less than 2%.

In order to read one of the analog channels, the channel address is placed on the address lines, and the ramp-start input (pin 3) is set low. The ramp-stop output (pin 7) goes high at this time. With the address lines stable for a signal-acquisition time of about 1 ms, the ramp capacitor, C1, charges to the voltage



Number	Type	+5 V	GND
IC1	μA9708	14	5
IC2	74LS221	16	8
IC3	74LS221	16	8
IC4	74LS393	14	7
IC5	74LS393	14	7
IC6	74150	24	12
IC7	74LS08	14	7
IC8	74LS02	14	7

Figure 1: *Schematic diagram of the A/D converter. Inputs I1 thru I6 of IC1 are the user's analog-input channels. The input voltage is converted to a binary number in the counter (IC4 and IC5), where it is retained until needed. The binary output is read in bit-serial fashion by the output multiplexer, IC6. Interface to the computer is through an 8-bit I/O port.*

Easy selection of 8 or 10 bits of accuracy is accomplished by installing the clock timing components (C6, C7, R8, and R9) on a DIP header (see figure 2).

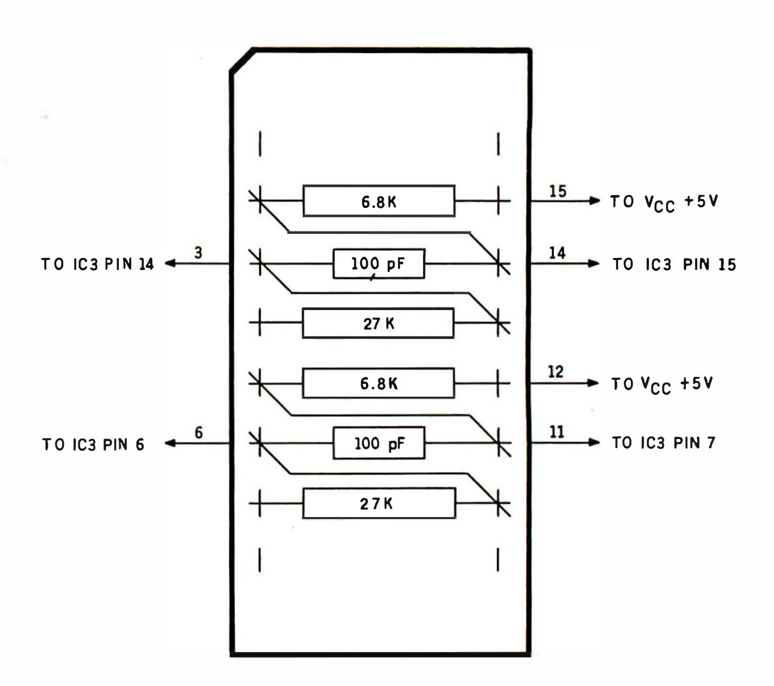


Figure 2: *Wiring of the DIP header (top view). This optional feature may be installed for easy selection of 8 or 10 bits of accuracy. The clock timing components are mounted on the header in such a way that when it is reversed in its socket, the time constants of IC3 (a 74LS221 monostable multivibrator) are appropriately changed.*

Listing 1: *A program segment, written for the 6502 microprocessor, that illustrates use of the A/D converter. Hexadecimal 10 is added to the channel address, and this value is then written to the interfacing I/O port to start the conversion. Data from the counter is read when needed.*

Address	Object Code	Label	Mnemonics	Comments
0250	A9 10		LDA H#10	;CHANNEL 0 ADDRESS
0252	8D 01 A8		STA DRA	;INITIATE A/D CONVERSION
0255	20 30 03		JSR RDADC	;READ CHANNEL 0 COUNT
0258	85 D0		STA D0	
025A	86 D1		STX D1	
025C	A9 17		LDA H#17	;CHANNEL 7 ADDRESS
025E	8D 01 A8		STA DRA	;INITIATE A/D CONVERSION
0261	20 30 03		JSR RDADC	;READ CHANNEL 7 COUNT
0264	85 C0		STA C0	
0266	86 C1		STX C1	
0268	A9 11		LDA H#11	;CHANNEL 1 ADDRESS
026A	8D 01 A8		STA DRA	;INITIATE A/D CONVERSION
026D	A9 02		LDA H#02	
026F	20 7C 05		JSR SUBM	;COUNT(REF) – COUNT(0)
0272	A5 C0		LDA C0	
0274	A6 C1		LDX C1	
0276	85 A0		STA A0	;SAVE CORRECTED REF COUNT
0278	86 A1		STX A1	
027A	20 30 03		JSR RDADC	;READ CHANNEL 1 COUNT
027D	85 C0		STA C0	
027F	86 C1		STX C1	
0281	A9 02		LDA H#02	
0283	20 89 05		JSR CMPM	;IS COUNT(1) < COUNT(0)?
0286	10 08		BPL SKIP	
0288	A5 D0		LDA D0	;SET COUNT(1)
028A	85 C0		STA C0	; TO
028C	A5 D1		LDA D1	; COUNT(0).
028E	85 C1		STA C1	;
0290	A9 02	SKIP:	LDA H#02	
0292	20 7C 05		JSR SUBM	;COUNT(1) – COUNT(0)

at the selected input. The ramp-start input is then set high. This disconnects the input voltage from the ramp capacitor, which now discharges linearly at a controlled rate through resistors R1 and R2. When the ramp capacitor is discharged, the ramp-stop output goes low. Since the capacitor's discharge time is directly proportional to the input voltage, a counter running during the interval from the conditions ramp-start-high to ramp-stop-low will, at the end, contain a count that is proportional to input voltage.

In this circuit, a low-to-high transition of peripheral-port bit 4 triggers IC2, a 74LS221 monostable multivibrator. Its Q output goes high to clear the counter, while the $\overline{Q}$ output holds the ramp-start line low, allowing the μA9708 (IC1) to acquire the voltage from the selected channel. Upon timing out, IC2's outputs change states, raising the ramp-start line to a high logic level and turning on the counter. When the ramp-stop line goes low, the counting stops, and peripheral-port bit 6 goes high to signal the computer that the conversion is complete. The counter value is the useful output of the converter, and is retained until it has been read and the next conversion cycle has begun.

The clock, IC3, is a multivibrator whose frequency is set to about 1 MHz by the 100 pF capacitors, C6 and C7, and 6.8 k-ohm resistors, R8 and R9, for a 10-bit count. An 8-bit count is selected by replacing R8 and R9 with 27 k-ohm resistors. If the frequency-determining components are installed symmetrically on a header, as shown in figure 2, the 8- or 10-bit counts can be selected by simply unplugging the header and reversing it.

A ripple counter and a 16-bit output multiplexer, controlled by address lines A0 thru A3, complete the circuit.

Before the circuit is used, all unused analog inputs should be grounded and the reference voltage and ramp slope should be set. The 10 k-ohm potentiometer, R3, is first adjusted until the reference voltage at pin 8 of IC1 is exactly 3 V, as in-

dicated by an accurate voltmeter. Then the converter connected to the computer is run in a loop, repeatedly addressing and reading the reference voltage at address 7. The 50 k-ohm potentiometer, R1, is adjusted until the count is just under hexadecimal FF for an 8-bit count, or hexadecimal 3FF for a 10-bit count.

In normal use, the program must first configure the peripheral-port bits 0 thru 4 as outputs and bits 5 thru 7 as inputs, and it must clear bit 4. Voltage readings are taken by writing the value of the channel address plus hexadecimal 10 to the peripheral port and then waiting until bit 6 goes high. The channel address should not be changed during this time. Reading of the counter data automatically clears peripheral port bit 4, enabling its low-to-high transition when the next address is written to the port. The counter is read a bit at a time by writing the address of the desired bit into the peripheral port, reading the port, and then left-shifting bit 7 (the counter data bit) into a register pair

Listing 2: *RDADC, a 6502 subroutine to read data from the counter in the converter. The 16-bit counter value is returned in the accumulator and X register. Status bits reflect the condition of the high-order byte.*

```
;                       ***** READ A/D CONVERTER *****
;            THIS SUBROUTINE READS THE COUNTER OF THE A/D CONVERTER.
;            IT RETURNS THE HIGH-ORDER BYTE IN THE ACCUMULATOR
;            AND THE LOW-ORDER BYTE IN THE X REGISTER.
;
;            SCRATCH LOCATIONS USED: F0,F1
;
0330  A9 40        RDADC:  LDA   H#40   ;LOAD MASK TO TEST BIT 6
0332  2C 01 A8       LP1:  BIT   DRA    ;IS A/D CONVERSION COMPLETED?
0335  50 FB                BVC   LP1    ;IF NOT, LOOP UNTIL DONE
0337  A2 0F                LDX   H#0F   ;LOAD INDEX REGISTER/COUNTER
0339  8E 01 A8       LP2:  STX   DRA    ;BIT ADDRESS
033C  AD 01 A8             LDA   DRA    ;READ BIT
033F  2A                   ROL   A      ;ROTATE ACCUMULATOR
0340  26 F1                ROL   F1     ;ROTATE MEMORY LOCATION F1
0342  26 F0                ROL   F0     ;ROTATE MEMORY LOCATION F0
0344  CA                   DEX
0345  10 F2                BPL   LP2    ;BRANCH IF POSITIVE
0347  A6 F1                LDX   F1     ;LOAD LOW-ORDER BYTE
0349  A5 F0                LDA   F0     ;LOAD HIGH-ORDER BYTE
034B  60                   RTS
```

Reference Designation	Part
IC1	μA9708, A/D converter
IC2,IC3	74LS221, monostable multivibrator
IC4,IC5	74LS393, dual 4-bit binary counter
IC6	74150, 1 of 16 data selectors
IC7	74LS02, quad 2-input NOR gate
IC8	74LS08, quad 2-input AND gate
C1	0.01 μF, polyester
C2	0.02 μF, ceramic
C3,C4,C5	0.1 μF, ceramic
C6,C7	100 pF, ceramic
R1	50 k-ohm, 10-turn potentiometer
R2	47 k-ohm, ¼ W, 5% tolerance
R3	10 k-ohm, 10-turn potentiometer
R4,R5	10 k-ohm, ¼ W, 10%
R6	15 k-ohm, ¼ W, 5%
R7	100 k-ohm, ¼ W, 10%
R8,R9	6.8 k-ohm or 27 k-ohm, ⅛ W, 5%

Table 1: *Parts list for circuit of figure 1. Capacitor C1 should be a low-leakage type. No precision tolerances are required.*

or 2 bytes of memory that will contain the 16-bit count. The sequence is repeated for each bit, starting with the most-significant bit at hexadecimal address 0F and ending with the least-significant bit at address 00.

The most efficient operation will result when the analog-to-digital conversion is initiated at a point in the program that occurs a number of instructions before the voltage reading is required. The computer is then free to execute the intervening instructions before having to wait for completion of the conversion. The hand-assembled program segment, shown in listing 1, illustrates the use of the converter and the RDADC subroutine (see listing 2). Note the instructions inserted between the initiation of the conversion at hexadecimal address 026A and the reading of the output at address 027A.

A nonzero count is always obtained, even when reading 0 V. This count must be subtracted from the reference voltage and channel counts. Thus, the computation for a linearized and scaled voltage reading becomes:

$$V(i) = \frac{\text{Count(Channel } i) - \text{Count (0)}}{\text{Count (7)} - \text{Count (0)}} \times V_{REF}$$

where V_{REF} is the reference voltage.

Long-term drift effects are minimized by reading the zero and reference voltages each time a channel is sampled. When reading very small input voltages, the possibility exists that a channel count may be smaller than the zero count. The apparent instability resulting from this condition is avoided by simply setting the channel count equal to the zero count.

The uses for such a converter are many and diverse. For example, if you are an energy-conscious homeowner, you may wish to monitor temperatures throughout your home. Or, if you are an amateur horticulturist, you may wish to monitor light intensity and temperatures of air and soil to optimize growing conditions for plants or cuttings. Whatever the application, I hope that this converter, with its 8 bits of accuracy for table subscripts or 10 bits of accuracy for better resolution, will serve you well. ■

Circle 163 on inquiry card.

A Votrax Vocabulary

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This vocabulary of 139 entries can be stored in as little as 770 bytes. The ASCII codes shown are for the TRS-80 voice synthesizer. Using Votrax symbology, however, this vocabulary is applicable to many other synthesizers, including the new SC01 phoneme speech chip.

*[In February, Kathryn Fons and Tim Gargagliano coauthored an article entitled "Articulate Automata" (February 1981 BYTE, page 164), in which they presented an overview of the physiology of speech and a look at how Votrax voice synthesizers are programmed. Since that article contained only general guidelines for programming voice synthesizers, they decided to provide us with more specific information in the form of this list of common computer terms and how they would be programmed....*SM]

```
A . . . . . . . . . . . .A1   AY   Y    Votrax
                         @    *    &    ASCII

B . . . . . . . . . . . .B    E1   AY   Y    Votrax
                         B    E    *    &    ASCII

C . . . . . . . . . . . .S    E1   AY   Y    Votrax
                         S    E    *    &    ASCII

D . . . . . . . . . . . .D    E1   AY   Y    Votrax
                         D    E    *    &    ASCII

E . . . . . . . . . . . .E1   Y    Votrax
                         E    &    ASCII

F . . . . . . . . . . . .EH1  EH2  F    Votrax
                         3    4    F    ASCII

G . . . . . . . . . . . .J    E1   AY   Y    Votrax
                         J    E    *    &    ASCII

H . . . . . . . . . . . .A1   AY   Y    T    CH   Votrax
                         @    *    &    T    C    ASCII

I . . . . . . . . . . . .AH1  EH3  I3   Y    Votrax
                         ;    5    #    &    ASCII

J . . . . . . . . . . . .D    J    EH3  A1   AY   Y    Votrax
                         D    J    5    @    *    &    ASCII

K . . . . . . . . . . . .K    EH3  A1   AY   Y    Votrax
                         K    5    @    *    &    ASCII

L . . . . . . . . . . . .EH1  EH3  UH3  L    Votrax
                         3    5    8    L    ASCII

M . . . . . . . . . . . .EH1  EH2  M    Votrax
                         3    4    M    ASCII

N . . . . . . . . . . . .EH1  EH3  N    Votrax
                         3    5    N    ASCII
```

```
O . . . . . . . . . . . .01  U1   Votrax
                         O    U    ASCII

P . . . . . . . . . . . .P    E1   AY   Y    Votrax
                         P    E    *    &    ASCII

Q . . . . . . . . . . . .K    Y1   IU   U1   U1   Votrax
                         K    Y    (    U    U    ASCII

R . . . . . . . . . . . .AH1  UH2  ER   Votrax
                         ;    7    /    ASCII

S . . . . . . . . . . . .EH1  EH3  S    Votrax
                         3    5    S    ASCII

T . . . . . . . . . . . .T    E1   AY   Y    Votrax
                         T    E    *    &    ASCII

U . . . . . . . . . . . .Y1   IU   U1   U1   Votrax
                         Y    (    U    U    ASCII

V . . . . . . . . . . . .V    E1   AY   Y    Votrax
                         V    E    *    &    ASCII

W . . . . . . . . . . . .D    UH1  B    UH3  L    Y1   IU   U1   Votrax
                         D    6    B    8    L    Y    (    U    ASCII

X . . . . . . . . . . . .EH1  EH2  K    PA0  S    Votrax
                         3    4    K    0    S    ASCII

Y . . . . . . . . . . . .W    AH1  EH3  I3   Y    Votrax
                         W    ;    5    #    &    ASCII

Z . . . . . . . . . . . .Z    E1   AY   Y    Votrax
                         Z    E    *    &    ASCII

ACCESS . . . . . . . . . .AE1  EH3  K    PA0  S    EH1  EH3  S    Votrax
                         9    5    K    0    S    3    5    S    ASCII

ADDRESS . . . . . . . . .AE1  EH3  D    R    EH1  EH3  S    Votrax
                         9    5    D    R    3    5    S    ASCII

AND . . . . . . . . . . .AE1  EH3  N    D    Votrax
                         9    5    N    D    ASCII

AUTOMATIC . . . . . . . .AW1  T    UH2  M    AE1  EH3  T    I1   K    Votrax
                         1    T    7    M    9    5    T    I    K    ASCII

BILLION . . . . . . . . .B    I1   I3   L    Y    UH3  N    Votrax
                         B    I    #    L    &    8    N    ASCII

BLOCK . . . . . . . . . .B    L    AH1  UH3  K    Votrax
                         B    L    ;    8    K    ASCII
```

Vocabulary continued on page 386

Vocabulary continued:

```
BREAK . . . . . . . .B    R    A1   AY   K    Votrax
                     B    R    @    *    K    ASCII

BUS . . . . . . . . .B    UH1  UH3  S    Votrax
                     B    6    8    S    ASCII

CABLE . . . . . . . .K    A1   Y    B    UH3  L    Votrax
                     K    @    &    B    8    L    ASCII

CHARACTER . . .K    EH1  R    EH1  K    T    ER   Votrax
               K    3    R    3    K    T    /    ASCII

CLEAR . . . . . . . .K    L    AY   I3   R    Votrax
                     K    L    *    #    R    ASCII

CLOSE . . . . . . . .K    L    O1   U1   Z    Votrax
                     K    L    O    U    Z    ASCII

CONTINUE . . . .K    UH1  N    T    I1   I3   N    Y1   IU   U1   Votrax
                K    6    N    T    I    #    N    Y    (    U    ASCII

COSINE . . . . . .K    O1   U1   S    AH1  EH3  Y    N    Votrax
                  K    O    U    S    ;    5    &    N    ASCII

DATA . . . . . . . . .D    AE1  EH3  T    UH2  UH3  Votrax
                      D    9    5    T    7    8    ASCII

DESK . . . . . . . . .D    EH1  EH3  S    K    Votrax
                      D    3    5    S    K    ASCII

DEVICE . . . . . . .D    EH1  EH3  V    UH3  AH2  Y    S    Votrax
                    D    3    5    V    8    A    &    S    ASCII

DISK . . . . . . . . .D    I1   I3   S    K    Votrax
                      D    I    #    S    K    ASCII

DISPLAY . . . . .D    I1   S    P    L    A1   I3   Y    Votrax
                 D    I    S    P    L    @    #    &    ASCII

DRIVE . . . . . . . .D    R    AH1  EH3  Y    V    Votrax
                     D    R    ;    5    &    V    ASCII

EDIT . . . . . . . . .EH1  D    I1   T    Votrax
                      3    D    I    T    ASCII

ELSE . . . . . . . . .EH1  EH3  L    S    Votrax
                      3    5    L    S    ASCII

ENABLE . . . . . . .EH1  N    A1   Y    B    UH3  L    Votrax
                    3    N    @    &    B    8    L    ASCII
```

```
END . . . . . . . . .EH1 EH3 N   D   Votrax
                     3   5   N   D   ASCII

ENTER . . . . . . .EH1 EH3 N   T   ER  Votrax
                   3   5   N   T   /   ASCII

ERASE . . . . . . .AY  I1  R   A1  AY  Y   S   Votrax
                   *   I   R   @   *   &   S   ASCII

ERROR . . . . . . .EH1 ER  O1  R   Votrax
                   3   /   O   R   ASCII

ESCAPE . . . . . .EH1 EH3 S   K   A1  Y   P   Votrax
                  3   5   S   K   @   &   P   ASCII

EXECUTE . . . . .EH1 K   PA0 S   EH1 K   Y1  IU  U1  T   Votrax
                 3   K   0   S   3   K   Y   (   U   T   ASCII

EXPONENT . . . .EH1 EH3 K   PA0 S   P   O1  U1  N   EH1 N   T
                3   5   K   0   S   P   O   U   N   3   N   T
                                                            Votrax
FEED . . . . . . . .F   E1  Y   D   Votrax                  ASCII
                    F   E   &   D   ASCII

FIELD . . . . . . .F   E1  Y   L   D   Votrax
                   F   E   &   L   D   ASCII

FIX . . . . . . . . .F   I1  I3  K   PA0 S   Votrax
                     F   I   #   K   0   S   ASCII

FLOPPY . . . . . .F   L   AH1 UH3 P   Y   Votrax
                  F   L   ;   8   P   &   ASCII

FOR . . . . . . . . .F   O2  O2  R   Votrax
                     F   [   [   R   ASCII

FORMAT . . . . . .F   O2  O2  R   M   AE1 EH3 T   Votrax
                  F   [   [   R   M   9   5   T   ASCII

FORWARD . . . . .F   O2  O2  R   W   ER  D   Votrax
                 F   [   [   R   W   /   D   ASCII

FRAME . . . . . . .F   R   A1  AY  Y   M   Votrax
                   F   R   @   *   &   M   ASCII

FREE . . . . . . . .F   R   E1  Y   Votrax
                    F   R   E   &   ASCII

GET . . . . . . . . .G   EH1 EH3 T   Votrax
                     G   3   5   T   ASCII

GLITCH . . . . . .G   L   I1  I3  T   CH  Votrax
                  G   L   I   #   T   C   ASCII
```

Vocabulary continued on page 388

Vocabulary continued:

```
GOSUB . . . . . . . .G    O1   U1   S    UH1  UH3  B    Votrax
                     G    O    U    S    6    8    B    ASCII

GOTO . . . . . . . . .G   O1   U1   T    IU   U1   Votrax
                     G    O    U    T    (    U    ASCII

HUNDRED . . . . . .H      UH1  UH3  N    D    R    EH3  D    Votrax
                     H    6    8    N    D    R    5    D    ASCII

IF . . . . . . . . . .I1  I3   F    Votrax
                     I    #    F    ASCII

INKEY . . . . . . . .I1   I3   N    K    AY   Y    Votrax
                     I    #    N    K    *    &    ASCII

INPUT . . . . . . . .I1   I3   N    P    OO   T    Votrax
                     I    #    N    P    $    T    ASCII

INSTRING . . . .I1        I3   N    S    T    R    I1   I3   NG   Votrax
                     I    #    N    S    T    R    I    #    +    ASCII

INSTRUCTION .I1           I3   N    S    T    R    UH1  K    SH   UH1  N Votrax
                     I    #    N    S    T    R    6    K    >    6    N ASCII

KEYBOARD . . . .K         AY   Y    B    O1   O2   R    D    Votrax
                     K    *    &    B    O    [    R    D    ASCII

KILL . . . . . . . . .K   I1   I3   L    Votrax
                     K    I    #    L    ASCII

LEFT . . . . . . . . .L   EH1  EH3  F    T    Votrax
                     L    3    5    F    T    ASCII

LEN . . . . . . . . . .L  EH1  EH3  N    Votrax
                     L    3    5    N    ASCII

LENGTH . . . . . . .L     EH1  EH3  N    TH   Votrax
                     L    3    5    N    =    ASCII

LEVEL . . . . . . . .L    EH1  EH3  V    UH3  L    Votrax
                     L    3    5    V    8    L    ASCII

LINE . . . . . . . . .L   AH1  Y    N    Votrax
                     L    ;    &    N    ASCII

LIST . . . . . . . . .L   I1   I3   S    T    Votrax
                     L    I    #    S    T    ASCII

LOAD . . . . . . . . .L   O1   U1   D    Votrax
                     L    O    U    D    ASCII

LOCK . . . . . . . . .L   AH1  UH3  K    Votrax
                     L    ;    8    K    ASCII
```

```
LOG . . . . . . . . . .L    AW2  AW2  G    Votrax
                       L    2    2    G    ASCII

MANUAL . . . . . . . .M    AE1  EH3  N    Y1   U1   UH3  L    Votrax
                       M    9    5    N    Y    U    8    L    ASCII

MEMORY . . . . . . . .M    EH1  EH3  M    O2   O2   R    Y    Votrax
                       M    3    5    M    [    [    R    &    ASCII

MERGE . . . . . . . . .M    ER   D    J    Votrax
                       M    /    D    J    ASCII

MID . . . . . . . . . .M    I1   I3   D    Votrax
                       M    I    #    D    ASCII

MODEL . . . . . . . . .M    AH1  UH3  D    UH3  L    Votrax
                       M    ;    8    D    8    L    ASCII

MICRO . . . . . . . . .M    UH3  AH2  AY   K    R    O1   U1   Votrax
                       M    8    A    *    K    R    O    U    ASCII

MILLION . . . . . . . .M    I1   I3   L    Y    UH3  N    Votrax
                       M    I    #    L    &    8    N    ASCII

NAME . . . . . . . . . .N    A1   AY   Y    M    Votrax
                       N    @    *    &    M    ASCII

NEXT . . . . . . . . . .N    EH1  EH3  K    PA0  S    T    Votrax
                       N    3    5    K    0    S    T    ASCII

NEW . . . . . . . . . .N    IU   U1   U1   Votrax
                       N    (    U    U    ASCII

NOT . . . . . . . . . .N    AH1  UH3  T    Votrax
                       N    ;    8    T    ASCII

ON . . . . . . . . . . .AH1  UH3  N    Votrax
                       ;    8    N    ASCII

OPEN . . . . . . . . . .O1   P    I1   N    Votrax
                       O    P    I    N    ASCII

OR . . . . . . . . . . .O1   O2   R    Votrax
                       O    [    R    ASCII

OUT . . . . . . . . . .UH3  AH2  U1   T    Votrax
                       8    A    U    T    ASCII

PEEK . . . . . . . . . .P    E1   Y    K    Votrax
                       P    E    &    K    ASCII

PHASE . . . . . . . . .F    A1   AY   Y    Z    Votrax
                       F    @    *    &    Z    ASCII
```

Vocabulary continued on page 390

Vocabulary continued:

POINT	P	01	I3	AY	N	T	Votrax		
	P	0	#	*	N	T	ASCII		
POKE	P	01	U1	K	Votrax				
	P	0	U	K	ASCII				
POSITION	P	UH1	UH3	Z	I1	SH	UH3	N	Votrax
	P	6	8	Z	I	>	8	N	ASCII
POWER	P	AH1	UH3	W	ER	Votrax			
	P	;	8	W	/	ASCII			
PRINT	P	R	I1	I3	N	T	Votrax		
	P	R	I	#	N	T	ASCII		
PUT	P	001	001	T	Votrax				
	P	%	%	T	ASCII				
RANDOM	R	AE1	EH3	N	D	UH1	M	Votrax	
	R	9	5	N	D	6	M	ASCII	
READ	R	E1	Y	D	Votrax				
	R	E	&	D	ASCII				
REMARK	R	E1	M	AH1	R	K	Votrax		
	R	E	M	;	R	K	ASCII		
REPEAT	R	E1	P	E1	AY	T	Votrax		
	R	E	P	E	*	T	ASCII		
RESET	R	E1	S	EH1	EH3	T	Votrax		
	R	E	S	3	5	T	ASCII		
RESTORE	R	E1	S	T	02	02	R	Votrax	
	R	E	S	T	[	[	R	ASCII	
RESUME	R	E1	Z	IU	U1	U1	M	Votrax	
	R	E	Z	(	U	U	M	ASCII	
RETURN	R	E1	T	ER	R	N	Votrax		
	R	E	T	/	R	N	ASCII		
REWIND	R	E1	W	AH1	AY	Y	N	D	Votrax
	R	E	W	;	*	&	N	D	ASCII
RIGHT	R	UH3	AH2	Y	T	Votrax			
	R	8	A	&	T	ASCII			
SAVE	S	A1	AY	Y	V	Votrax			
	S	@	*	&	V	ASCII			
SELECT	S	EH2	L	EH1	K	PA0	T	Votrax	
	S	4	L	3	K	0	T	ASCII	

```
SET . . . . . . . . . .S    EH1  EH3  T    Votrax
                       S    3    5    T    ASCII

SHIFT . . . . . . . . .SH   I1   I3   F    T    Votrax
                       >    I    #    F    T    ASCII

SINE  . . . . . . . . .S    AH1  EH3  Y    N    Votrax
                       S    ;    5    &    N    ASCII

STEP  . . . . . . . . .S    T    EH1  EH3  P    Votrax
                       S    T    3    5    P    ASCII

STOP  . . . . . . . . .S    T    AH1  UH3  P    Votrax
                       S    T    ;    8    P    ASCII

STRING  . . . . . . . .S    T    R    I1   I3   NG   Votrax
                       S    T    R    I    #    +    ASCII

SUPPLY  . . . . . . . .S    UH1  P    L    AH1  EH3  Y    Votrax
                       S    6    P    L    ;    5    &    ASCII

SYSTEM  . . . . . . . .S    I1   S    T    EH1  M    Votrax
                       S    I    S    T    3    M    ASCII

TAB . . . . . . . . . .T    AE1  EH3  B    Votrax
                       T    9    5    B    ASCII

TANGENT . . . . . . . .T    AE1  EH3  N    D    J    EH1  N    T    Votrax
                       T    9    5    N    D    J    3    N    T    ASCII

THEN  . . . . . . . . .THV  EH1  EH3  N    Votrax
                       <    3    5    N    ASCII

TIME  . . . . . . . . .T    AH1  EH3  Y    M    Votrax
                       T    ;    5    &    M    ASCII

TRACE . . . . . . . . .T    R    A1   AY   Y    S    Votrax
                       T    R    @    *    &    S    ASCII

THOUSAND  . . . . . . .TH   AH1  UH3  U1   Z    EH3  N    D    Votrax
                       =    ;    8    U    Z    5    N    D    ASCII

USER  . . . . . . . . .Y1   IU   U1   U1   Z    ER   Votrax
                       Y    (    U    U    Z    /    ASCII

USING . . . . . . . . .Y1   IU   U1   U1   Z    I1   I3   NG   Votrax
                       Y    (    U    U    Z    I    #    +    ASCII

VALUE . . . . . . . . .V    AE1  EH3  L    Y1   IU   U1   Votrax
                       V    9    5    L    Y    (    U    ASCII

ZAPPED  . . . . . . . .Z    AE1  EH3  P    PA0  T    Votrax
                       Z    9    5    P    0    T    ASCII
```

The Impossible Dream:

Computing e to 116,000 Places with a Personal Computer

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The 1960s were a decade of unrest, turbulence, and accomplishment. Man walked on the moon, *Star Trek* was launched, and the first million digits of π were determined by a computer. Today, as we face the early 1980s, Robert Truax, a backyard hobbyist, is constructing a private spacecraft, *Star Trek* has been revived as a movie, and personal computers are a reality. As a people, passion drives us to explore the unknown reaches of our universe. It is pleasing to note that this exploration is no longer the exclusive domain of governments and large institutions.

The purpose of this article is to share my experiences in computing the mathematical constant e to 116,000 digits of precision on an Apple II computer. Although this computation has little intrinsic value or use, the experience was stimulating and educational. The problems I was forced to overcome gave me insights that greatly contributed to new floating-point routines. These routines were, in some cases, two to three times as fast as those currently implemented in some of our languages at Apple. Because I wanted to develop my own solutions to the problem, I did not research existing techniques for computing e to great precision. Therefore, my approaches are quite possibly not state-of-the-art.

I first calculated e to 47 K bytes of precision in January 1978. The program ran for 4.5 days, and the binary result was saved on cassette tape. Because I had no way of detecting lost-bit errors on the Apple (16 K-byte dynamic memory circuits were new items back then), a second result, matching the first, was required. Only then would I have enough confidence in the binary result to print it in decimal.

Before I could rerun the 4.5 day program successfully, other projects at Apple, principally the floppy-disk controller, forced me to deposit the project in the bottom drawer. This article, already begun, was postponed along with it. Two years later, in March 1980, I pulled the e project out of the drawer and reran it, obtaining the same results. As usual (for some of us), writing the magazine article consumed more time than that spent meeting the technical challenges.

Just before this issue went to press, Steve Wozniak told me that he had redesigned the theoretical "e-machine" that uses dedicated hardware for calculating e. The machine, which costs under $10,000, would use disk storage on a hard disk to replace large amounts of programmable memory. Steve estimates that a calculation of e to 100,000,000 places (ten times as many places as the current calculation of e) could be made in three months of calculation time.... **GW**

Little Things Add Up

To compute the value of e, a method or formula must be found or derived. The *CRC Standard Mathematical Tables* handbook (see references) provides the well-known formula:

$$e = 1 + 1/1! + 1/2! + 1/3! + \ldots$$

We know that e is approximately 2.71828. For the sake of simplicity, we will deal with the fractional part only (.71828, etc) and abbreviate it *efrac*.

$$efrac = 1/2! + 1/3! + 1/4! + \ldots$$

Because each term is less than one-half the prior term, this series converges with the property that the sum of all terms beyond a specified nth term is less than that nth term. Thus, if the series is truncated after n terms, the maximum error in the computation is less than $(1/n!)$. This property relates the number of terms used, n, to the precision obtained in the computation. Because this series contains a factorial in the denominator of the terms, it is said to converge rapidly. This means that great precision can be obtained with relatively few terms. For example,

the *CRC Standard Mathematical Tables* handbook lists 100! as 9.3326×10^{157}, signifying that 100 terms will yield almost 158 digits of precision. The rate of convergence is sufficient that, for the problem at hand, neither algebraic manipulation of the series for faster convergence nor selection of a different formula is necessary.

Divide and Conquer

The following algorithm accomplishes the evaluation of the series for *e*. Of course, all critical routines should be implemented in highly optimized machine (assembly) language for speed. An extra hour spent optimizing the innermost loops could save days of computation time. Even self-modifying code should be used to save a critical microsecond! Binary arithmetic should be used to obtain maximal precision and the fastest possible computation time. Later, the result can be converted to decimal as it is printed.

The algorithm is as follows (also see figure 1):

1. Divide available memory equally into two arrays, TERM and E. The TERM array will contain successive terms ($1/i!$) and is initialized to 0.5 ($^1/_2!$). The E array will contain the running total of the terms and is also initialized to 0.5. Both arrays can be thought of as long bit streams of the fractional parts of the numbers they represent.
2. Set the variable DIVISOR to an initial value of 3.
3. Divide TERM by DIVISOR, forming 1/(DIVISOR!). Multiprecision division techniques will be discussed later.
4. Add TERM to E, keeping the assumed decimal points aligned. This sum will always be purely fractional (ie: it will never equal or exceed 1).
5. Increment the DIVISOR variable.
6. Repeat steps 3, 4, and 5 until TERM is reduced to all zeros or until a predetermined maximum divisor is reached.

This basic computation algorithm utilizes only 50% of available memory for the result. By rearranging the series for *e*, we can arrive at an approach that utilizes 100% of the memory.

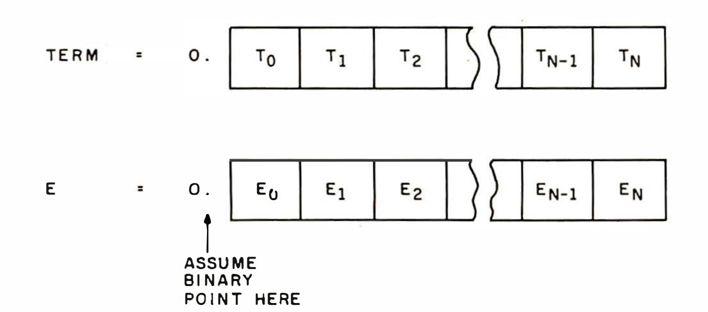


Figure 1: *Memory usage in the first algorithm to calculate e. Equal amounts of memory are devoted to a sequence of bytes representing the value of the current term being calculated (TERM) and the sum of all terms calculated thus far (E). Both numbers are seen as binary fractions (ie: the leftmost bit represents ½, the next bit represents ¼, etc).*

We begin by reversing the order of terms in *efrac*:

$$efrac = 1/2! + 1/3! + \ldots + 1/(n-1)! + 1/n! \ (n \text{ terms})$$
$$= 1/n! + 1/(n-1)! + \ldots + 1/3! + 1/2!$$

We then develop the following identity:

$$\frac{1}{i\,!} + \frac{1}{(i-1)!} = \frac{1}{i(i-1)!} + \frac{1}{(i-1)!}$$

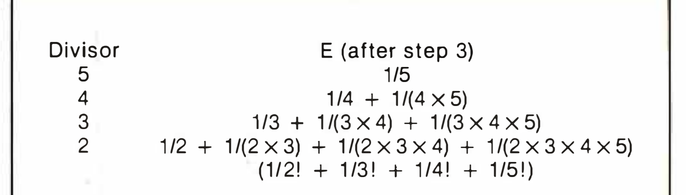
$$= \frac{\frac{1}{i} + 1}{(i-1)!}$$

By repeatedly applying this identity to the formula, we get:

$$efrac = \cfrac{\cfrac{\cfrac{\cfrac{\frac{1}{n}+1}{(n-1)}+1}{\vdots}+1}{3}}{2}$$

On inspection, the second series is equivalent to the first for *n* terms. A notable property of the new series is that the computation begins with the *n*th (greatest) divisor and ends with 2 (the smallest). The algorithm for computing *e* with this series is as follows:

1. Allocate all available memory to the E array (which stores the value of *efrac*, the fractional part of *e*). Initialize it to zero.
2. Set the initial value of DIVISOR to *n*, the precalculated maximum term (where *n*! is greater than the precision of the result to be computed).
3. Add 1 to E and divide by the current DIVISOR. The addition may simply imply setting the carry before dividing.
4. Decrement the DIVISOR.
5. Repeat steps 3 and 4 until the divisor equals 1.



Divisor	E (after step 3)
5	1/5
4	1/4 + 1/(4 × 5)
3	1/3 + 1/(3 × 4) + 1/(3 × 4 × 5)
2	1/2 + 1/(2 × 3) + 1/(2 × 3 × 4) + 1/(2 × 3 × 4 × 5)
	(1/2! + 1/3! + 1/4! + 1/5!)

Table 1: *Example of the calculation of e by the first algorithm.*

An example of this algorithm for $n=5$ is given in table 1.

How Large Is It?

An associate of mine once discovered that integrated circuit layouts could be conveniently specified in nanoacres! In the computation of e, it is more meaningful to specify the precision of the result in decimal digits rather than in the number of bytes allocated. The following formula performs the conversion:

$$\log_{10}(x) = \log_{256}(x) \times \log_{10}(256)$$
$$\text{(number of digits)} = \text{(number of bytes)} \times (2.40824)$$

For example, assume that 14 K bytes of memory are allocated to the fraction of e. The number of digits of accuracy this represents is given by the following:

$$\text{number of digits} = 14 \times 1024 \times 2.40824 = 34524.5 \text{ digits}$$

The process of calculating the number of terms needed to compute e to this precision is less straightforward. What must be determined is the minimum value of n, where $n!$ is greater than the precision corresponding to available memory. For the above example, this is the minimum n such that $n!$ is greater than 10^{34524}. The *CRC Standard Mathematical Tables* handbook lists Stirling's Formula, an equation useful for calculating the magnitude of $n!$ for reasonably large n:

$$\lim_{n \to \infty} \frac{n! \exp(n)}{n^{(n+0.5)}} = \sqrt{2\pi}$$

Taking the natural logarithms of both sides, we get:

$$\lim_{n \to \infty} \ln(n!) = \frac{\ln(2\pi)}{2} + [\ln(n)]\,[n+0.5] - n$$

Dividing by ln(10) to obtain the result in common (base-10) logarithms, we see the following:

$$\lim_{n \to \infty} \log_{10}(n!) = \frac{\log_{10}(2\pi)}{2} + [\log_{10}10(n)][n+0.5] - \frac{n}{\ln(10)}$$

The integer portion of this result gives us one less than the number of digits in $(n!)$.

The HP-41C calculator program in listing 1 calculates $\log_{10}(n!)$ (the number of digits in $n!$), given n.

By trial and error, it is easy to zero in on the minimum n for which $\log_{10}(n!)$ is greater than 34,524, the number of digits of precision corresponding to 14 K bytes of memory. Table 2 shows a set of values for n in the order in which they were calculated to find the desired value.

The value 9716 is found to be the minimum suitable value of n. Because it is difficult to relate the precision of $n!$ to that of $1/n!$, a slightly higher value (perhaps 9720) should be used for n. This will also compensate for minor formula or calculation errors.

A Multiprecision Division Algorithm

The problem at hand calls for the division of a very large dividend (possibly several kilobytes) by a moderate divisor (2 bytes). The general approach is to shift the divisor relative to the dividend, from the most significant bits toward the least, performing the familiar subtract/replace and shift technique that we call long division.

A few general optimizations should be considered. First, the following algorithm assumes that the divisor is less than 32,768 (2^{15}). If the divisor were to exceed 32,768, it would have to be compared to a value that could exceed 16 bits (2 bytes). Because indexed operations on the 6502 microprocessor are slower than absolute, direct, zero-page, or register operations, a few "fast" memory locations are allocated to hold the temporary (ie: relating to the current byte) dividend/quotient, and remainder. These locations are designated A0 (dividend/quotient), and A1 and A2 (2-byte remainder), and they should be allocated to the most accessible memory locations (or registers). The high-order byte of

Listing 1: *The FACTLOG program for the Hewlett-Packard HP-41C calculator. This program calculates the approximate number of digits in the number (n!).*

```
LBL ALPHA FACTLOG ALPHA ENTER LOG LASTX .5 + *
x<>y 10 LN / -
PI ENTER + LOG 2 / + RTN
```

the fraction array E is assumed to be E(0), and the low-order byte is E(n). Remember that the 2-byte divisor, NH and NL, represents a whole number, and that the dividend represents a binary fraction with the binary point directly to the left of the MSB (most significant bit) of E(0).

In the algorithm that follows, the A0 byte represents the current byte, E(i), of the dividend at step 2. By step 6, however, all the digits of the dividend have been shifted out to the left (to the A1, A2 combination), and the digits of the new quotient have been shifted into A0 from the right. A0 is actually doing the work of two 8-bit registers.

Of course, all computation should be done in binary for maximum precision and speed. While targeted for 8-bit machines, these techniques are applicable to machines of longer word lengths.

The "add 1 and divide by n" algorithm (see figure 2) is as follows:

n	$\log_{10}(n!)$ (number of digits in $n!$)
10000	35659.5
9000	31681.9
9700	34461.4
9800	34860.3
9730	34581.0
9720	34541.2
9710	34501.3
9715	34521.2
9716	34525.2

Table 2: *Trial-and-error determination of the number of terms, n, needed to obtain 34,524 digits of precision in the calculation of e. In the algorithm used to calculate e, the smallest contribution to the final value is made by the term (1/n!). The number of digits in (n!) is determined by estimating the value of n! and taking the logarithm to the base 10. The desired value of n is the first integer value greater than 34,524.*

1. Initialize the remainder (locations A2 and A1) to 1, effectively adding 1.0 to the fractional dividend prior to dividing. (A2 is the most significant byte of the remainder.) This accommodates the algorithm developed for calculating e. An unmodified divide operation would call for initializing the remainder to zero. Initialize the index, i, to zero.
2. Move the next dividend byte, E(i), to location A0 to divide it by n. Shift A0 left 1 bit, moving the MSB into the carry bit.
3. Rotate the 16-bit remainder (A2 and A1) to the left by 1 bit, and rotate the carry bit from A0 into the LSB (least significant bit) of A1. This corresponds to the "shift" portion of the subtract-and-shift algorithm for division. No overflow can occur from this shift because the residual remainder must be less than twice the divisor, which in turn is less than 32,768 (2^{15}).
4. Compare the remainder, A2 and A1, to the divisor locations NH and NL. If the remainder is greater, then replace it with the difference of the two and set the quotient bit to 1. Otherwise, clear the quotient bit.
5. Rotate the quotient bit into the LSB of A0, and rotate the MSB of A0 into the carry bit.
6. Perform steps 3, 4, and 5, a total of eight times. Then replace E(i) with the byte in A0 (which is now the quotient of the byte-wide division just finished). Increment the index, i, and continue at step 2 until the last byte, E(n), has been processed.

Special Optimizations

I drive a small car and have found that it is helpful to accelerate or decelerate slightly in advance of certain stretches of the road (especially hills and downgrades) to obtain an adequate performance. Similarly, it is

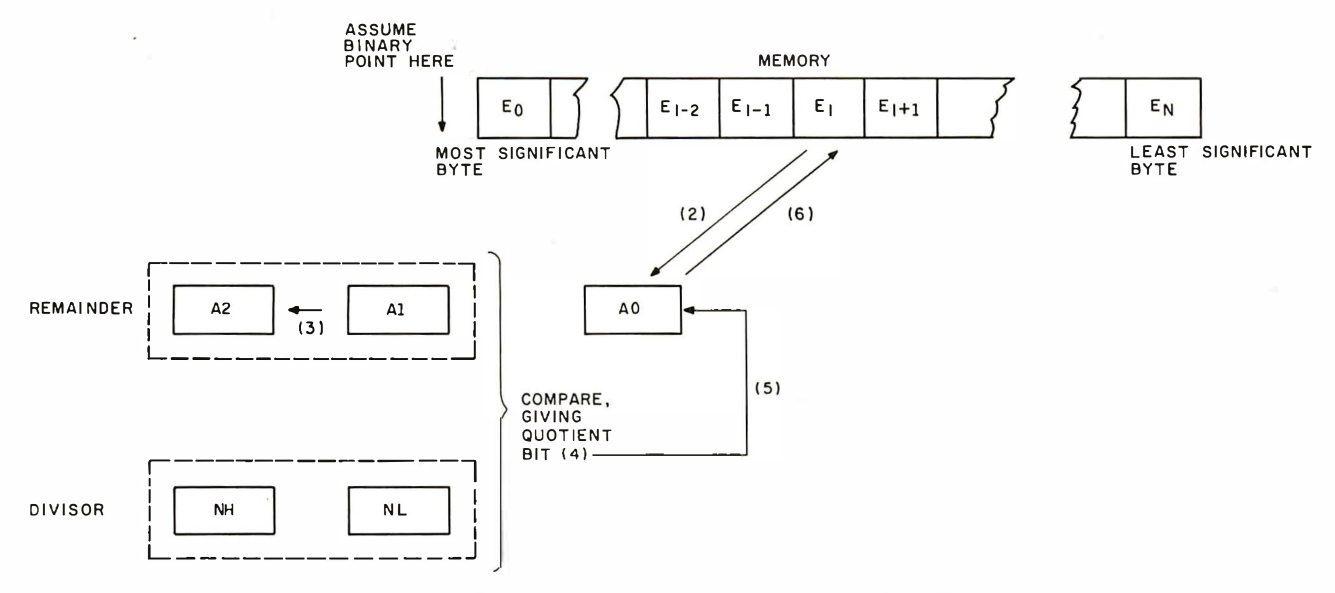


Figure 2: *Memory usage in the multiple-byte "add 1 and divide by n" division algorithm. The second algorithm (given in the text) reduces memory usage by 50% by using one long string of bytes in the computation process. The E array is divided 1 byte at a time by the 2-byte divisor. The A0 byte is used to store both the dividend and the quotient at different points in the algorithm. The numbers in parentheses refer to numbered steps in the algorithm.*

sometimes necessary to compensate for the inherent deficiencies of microprocessors (eg: their size) by carefully implementing specific optimizations. For example, the comparison performed in step 4 (discussed above) would normally be done by subtracting the low, and then high bytes, and possibly preserving the difference for replacement of the remainder. Within certain processors, it may be faster to first compare the high bytes, since they frequently dictate the comparison result (255 out of 256 times for arbitrary contents). Also, the critical steps 3, 4, and 5 can be coded eight times in-line to avoid the overhead time of a loop. And because the divisor changes infrequently, it can be coded as fast immediate-mode data. After each full divide, the code, which resides in programmable memory, can be modified for the next divisor.

The 6502 assembly-language program in listing 2 calculates *e* in 14 K bytes of memory. In order to keep the listing brief for this article, the program is not fully optimized. The major operation (add 1, divide) is not coded in-line eight times but is instead implemented as a loop. Because the Y register is used as a loop counter, it is not available as an index to the *e* array, and time-consuming increment instructions must be performed on the instructions at EREF1 and EREF2. Also, it is slightly faster not to move the current dividend byte of *e* into a separate fast location (A0 in the algorithm).

The *e* array begins at hexadecimal location 800 (which is the most significant byte of the array). This secondary text-screen page of the Apple II allows you to view roughly the first 1 K bytes of *e* as they are calculated. Although the character representation is not readily useful, it is at least comforting to observe that the program is working on the correct section of memory. Do not execute this program until you read further and have a good idea of how long it runs before completion. Also, remember that although the result is in binary and somewhat meaningless, it will later be converted to decimal and printed.

Tomorrow Is a Long Time

The execution time of this program is proportional to the number of divisions performed (9719 for the above example), the number of bytes being divided (14 K bytes in this case), and the average divide time per byte.

The average divide time per byte is calculated as follows. In listing 2, the numbers in parentheses are the cycle times of all significant instructions of the divide routine. Careful analysis shows that when the high-order dividend (remainder) byte is less than the high-order divisor byte, 23 cycles are used. When the former is greater than or equal to the latter, 39 cycles are used, with approximately 13.5 additional cycles (on the average) if the two are equal. Statistically, the remainder will be less than the divisor half of the time and greater than or equal to the divisor half of the time. Analysis reveals that the 2 bytes will be equal approximately one out of every $2H$ comparisons, where H is the high-order divisor

byte contents. In the example, H varies from 37 down to 0, so the average frequency of equality is 1 in 37. Using this "fudge factor," the average cycle time per 1-bit partial division is computed as follows:

$$\text{cycles per bit} = {}^{23}/_{2} + {}^{39}/_{2} + {}^{13.5}/_{37} = 31.3649 \text{ cycles}$$

Every byte divided includes eight of the above iterations plus an overhead of 21 cycles, giving the following average:

$$\text{cycles per byte} = (\text{cycles per bit} \times 8 \text{ bits per byte}) + 21 = 31.3649 \times 8 + 21 = 271.919 \text{ cycles}$$

The average time per cycle on the Apple II is a function of the crystal frequency (14.31818 MHz) and the fre-

Text continued on page 399

Listing 2: *A 6502 machine-language program for calculating e to 34,524 decimal digits. The result is in binary and must be converted to decimal by the programs shown in listings 3 and 4.*

```
SOURCE FILE: ECALC1
0000:                    LSTON
0000:         ***********************************
0000:         *                                 *
0000:         *    CALCULATION OF E -- 14K      *
0000:         *                                 *
0000:         *      WOZ        20-APR-80       *
0000:         *                                 *
0000:         *        EXAMPLE PROGRAM          *
0000:         *                                 *
0000:         ***********************************
0000:         *                                 *
0000:         *  LOCATIONS $800-3FFF ARE USED   *
0000:         *  FOR THE (BINARY) FRACTION OF   *
0000:         *  E. LOCATION $800 IS THE MOST   *
0000:         *  SIGNIFICANT BYTE, $3FFF IS     *
0000:         *  THE LEAST SIGNIFICANT.  THIS   *
0000:         *  CORRESPONDS TO APPROXIMATELY   *
0000:         *  34524 DIGITS.                  *
0000:         *                                 *
0000:         ***********************************
0000:         *                                 *
0000:         *  THE FIRST DIVISOR IS 9720      *
0000:         *  AND THE LAST IS 2.  9720       *
0000:         *  FACTORIAL IS GREATER THAN      *
0000:         *  10 ^ 34524.                    *
0000:         *                                 *
0000:         ***********************************
0000:         *                                 *
0000:         *  THE MAJOR OPERATION IS AN      *
0000:         *  INCREMENT (+1) OF E FOLLOWED   *
0000:         *  BY A MULTI-PRECISION DIVIDE    *
0000:         *  BY THE CURRENT DIVISOR.        *
0000:         *  EACH SUCCESSIVELY LESS SIG-    *
0000:         *  NIFICANT BYTE OF E, TOGETHER   *
0000:         *  WITH THE RESIDUAL REMAINDER    *
0000:         *  A1 AND A2, IS DIVIDED BY THE   *
0000:         *  CURRENT 2-BYTE DIVISOR.  THE   *
0000:         *  8-BIT QUOTIENT IS LEFT IN E    *
0000:         *  AND THE RESIDUAL REMAINDER     *
0000:         *  IN A1 AND A2 (ACC HOLDS A2).   *
0000:         *                                 *
0000:         ***********************************
0000:         A1       EQU  0          (CURRENT BYTE OF E IS A0, ACC IS A2)
0001:         PCOUNT   EQU  1          COUNTS RAM PAGES OF E ARRAY.
```

Listing 2 continued on page 398

Listing 2 continued:

```
0800:             E        EQU  $800        E, BINARY FRACTION, TO $3FFF.
0038:             NUMPAG   EQU  $38         14K IS 56 RAM PAGES.
25F8:             N        EQU  9720        (N FACTORIAL IS > 34524 DIGITS)
25F8:             NL       EQU  N&$FF       LO BYTE OF N.
0025:             NH       EQU  N/256       HI BYTE OF N.

----- NEXT OBJECT FILE NAME IS ECALC1.OBJ0
0240:                      ORG  $240
0240:A9 38        NXTDVSR  LDA  #NUMPAG     INIT RAM PAGE COUNTER
0242:85 01                 STA  PCOUNT        FOR 56 PAGES.
0244:A9 01                 LDA  #1
0246:85 00                 STA  A1          INIT RESIDUAL REMAINDER TO 1. (FOR +1)
0248:A9 08                 LDA  #E/256
024A:8D 5C 02              STA  EREF1+2     MODIFY CODE SO THAT REFS
024D:8D 78 02              STA  EREF2+2       TO E POINT TO FIRST BYTE.
0250:A9 00                 LDA  #0          (ACC IS ALSO A2 OF RESIDUAL REMAINDER)
0252:8D 5B 02              STA  EREF1+1
0255:8D 77 02              STA  EREF2+1
0258:A0 08        NXTBYTE  LDY  #8          (2) COUNTER--8 BITS PER BYTE.
025A:0E 00 08     EREF1    ASL  E           (6) MSB OF DIVIDEND BYTE TO CARRY.
025D:26 00        NXTBIT   ROL  A1          (5) SHIFT 3-BYTE DIVIDEND.
025F:2A                    ROL  A           (2)  (ACC IS A2)
0260:C9 25        NHREF1   CMP  #NH         (2) IF HI BYTE LESS THAN DIVISOR
0262:90 12                 BCC  EREF2       (3/2)   THEN QUOTIENT BIT IS 0.
0264:D0 06                 BNE  REPLACE     (3/2) (TAKEN IF GREATER)
0266:A6 00                 LDX  A1          (3) COMPARE LOW BYTES IF HI BYTES EQUAL.
0268:E0 F8        NLREF1   CPX  #NL         (2)
026A:90 0A                 BCC  EREF2       (3/2) IF LESS, QUOTIENT BIT IS 0.
026C:AA           REPLACE  TAX              (2)
026D:A5 00                 LDA  A1          (3) REPLACE RESIDUAL REMAINDER A1 AND A2
026F:E9 F8        NLREF2   SBC  #NL         (2)   WITH RESIDUAL REMAINDER
0271:85 00                 STA  A1          (3)   MINUS CURRENT DIVISOR.
0273:8A                    TXA              (2) (HI BYTE OF RESIDUAL REMAINDER)
0274:E9 25        NHREF2   SBC  #NH         (2) (GUARANTEED TO SET CARRY)
0276:2E 00 08     EREF2    ROL  E           (6) QUOTIENT BIT INTO A0 LSB, MSB TO CARRY.
0279:88                    DEY              (2) NEXT OF 8 BITS.
027A:D0 E1                 BNE  NXTBIT      (3/2) LOOP--NOTE: CARRY = QUOTIENT BIT.
027C:EE 5B 02              INC  EREF1+1     (5)
027F:EE 77 02              INC  EREF2+1     (5) MODIFY CODE REFS TO E ARRAY.
0282:D0 D4                 BNE  NXTBYTE     (3)  (NO BYTE OVERFLOW)
0284:EE 5C 02              INC  EREF1+2
0287:EE 78 02              INC  EREF2+2     (MODIFY HI BYTE)
028A:C6 01                 DEC  PCOUNT
028C:D0 CA                 BNE  NXTBYTE     LOOP UNTIL DONE 56 RAM PAGES.
028E:AD 69 02              LDA  NLREF1+1
0291:D0 06                 BNE  NXTDVR2
0293:CE 61 02              DEC  NHREF1+1    DECR IMMEDIATE REFS TO
0296:CE 75 02              DEC  NHREF2+1      CURRENT DIVISOR.
0299:CE 69 02     NXTDVR2  DEC  NLREF1+1
029C:CE 70 02              DEC  NLREF2+1
029F:AD 69 02              LDA  NLREF1+1
02A2:4A                    LSR  A
02A3:0D 61 02              ORA  NHREF1+1    LOOP IF DIVISOR > 1.
02A6:D0 98                 BNE  NXTDVSR
02A8:60                    RTS              (DONE)

*** SUCCESSFUL ASSEMBLY: NO ERRORS
```

Text continued from page 397:
quency-dividing circuitry that generates the microprocessor clock. Due to color-graphics considerations, a slight adjustment (to eliminate display jitter) is made, which introduces a constant multiplying the crystal period, and gives us the following time per machine cycle:

$$\text{time per cycle} = 912/((65)(14.31818\ \text{MHz})) = 0.9799269\ \mu s$$

The division time per byte (in μs) and time per program execution can now be calculated:

$$\begin{aligned}\text{time per byte} &= \text{cycles per byte} \times \text{time per cycle}\\ &= 271.919\ \text{cycles} \times .9799269\ \mu s\ \text{per cycle}\\ &= 266.46\ \mu s\\ \text{time per program} &= \text{time per byte} \times \text{number of bytes} \times \text{number of divisions}\\ &= 266.46\ \mu s \times (14)(1024) \times 9719\\ &= 37{,}126\ \text{seconds}\\ &= 10.3\ \text{hours}\end{aligned}$$

Note that as you compute *e* to greater precision, both the number of divisors and the length of each division increase. Also, at some point, a 2-byte division no longer suffices and a 3-byte division must be used. This causes the execution time to vary with roughly the second power of the precision sought. For example, three times the precision takes ten times as long to calculate!

Running the Example Program

If you wish to try the example program before branching out on your own, a few suggestions should be heeded. First, it is a shame to run a program for 10 hours and then find out it contained a minor bug. By changing N (the maximum divisor) to 1000 and NUMPAG to 4 (for 1 K bytes of precision), a quick trial/practice version can be assembled. The practice run allows the user to get the obvious mistakes out of the way with minimum consequence and verify that the assembly is correct. The following commands will clear the memory locations used, run the program, and finish in about 4.5 minutes (273 seconds). Hexadecimal location 0800 should contain B7, and location 0BFF should contain 24 upon completion. As mentioned previously, you can watch the calculation proceed by displaying the secondary text screen on the Apple II. During the trial run, it should be constantly changing.

The following two lines (to be entered when the Apple II is in monitor mode) allow you to run the test program:

```
*800:0 N801<800.BFEM
*C055 240G C054
```

The first line clears the area of memory that will be used, and the second line switches the video display to text page 2 (which will contain the value of *e* being computed), runs the program of listing 2, then returns to text page 1 when the program is complete.

The real (10-hour) example program should be run twice, and the results compared to verify that the program does not contain a minor bug and that the constants were properly determined. As discussed below, it is not necessary to initialize memory before running the program if the constant *n* has been properly selected. Therefore, it is recommended that the program be run first with initialized memory and later with random (uninitialized) memory. These results, when compared, should be identical. Once you have confidence in the binary result, save it on tape or floppy disk for printing in decimal.

Go Forth and Multiply

The computed binary fraction must next be converted to decimal and printed. The general method of converting a binary fraction to a decimal fraction is to repeatedly multiply it by decimal 10 (in binary). The carry from each multiplication (integer portion of product) is the next decimal digit. Because the most significant digits are generated first, the result can be printed as it is generated.

A higher-level language such as BASIC should be used to format the output, but unless you are planning a short vacation, highly optimized machine language should be used for the base conversion. The 6502 programs in listing 3 accomplish the conversion. Subroutine INIT is called once to generate a 256-entry, multiply-by-100 lookup table. Subroutine MULT scans the *e* array, from the least toward the most significant bytes, multiplying each byte by 100 via a fast table lookup. It also handles carries. The resultant carry is a 2-digit number between 0 and 99 that is returned to BASIC for printing. Note that multiplying by 100, instead of 10, generates 2 digits per pass.

Seeing Is Believing

The BASIC formatting program in listing 4 should produce an attractive printout. No single program will suffice, due to the fact that printers and people are so varied. The considerations include page headers (title, date, page number), lines per page, spacing between lines, digits per line, digit groupings (eg: groups separated by a space or two), and margins. For example, the poor horizontal registration of a Centronics 779 printer is painfully obvious with single-spaced printouts but almost undetectable with double-spaced ones. A little trial and error will insure that your printout is a perfect "10."

The program in listing 4 was used with an NEC (Nippon Electric Company) Spinwriter. It prints 60 digits per line (twelve groups of 5 digits, separated by single blanks) and 60 lines per page. The page heading is simply the letter *e* and the page number, carefully aligned with the left and right margins. The text "e=2." precedes the first digit of the printout. The program ends after printing 34,500 digits, despite the fact that an additional 24 digits are re-

Text continued on page 402

Listing 3: *A BASIC driver program to print e from binary to decimal form. The program uses the machine-language program EPRNT, shown in listing 4.*

```
SOURCE FILE: EPRNT
0000:     ************************************
0000:     *                                  *
0000:     *    'E' PRINTOUT ROUTINES         *
0000:     *                                  *
0000:     *         14K VERSION              *
0000:     *                                  *
0000:     *      WOZ       20-APR-80         *
0000:     *                                  *
0000:     ************************************
0000:     *                                  *
0000:     *  THESE SUBROUTINES PERFORM       *
0000:     *  THE CRITICAL OPERATIONS         *
0000:     *  FOR CONVERTING THE 14K          *
0000:     *  BINARY VERSION OF 'E'           *
0000:     *  TO DECIMAL FOR PRINTING.        *
0000:     *  THEY ARE INTENDED TO BE         *
0000:     *  CALLED FROM A BASIC PROGRAM     *
0000:     *  WHICH DOES THE ACTUAL           *
0000:     *  PRINTING.                       *
0000:     *                                  *
0000:     ************************************
0000:     *                                  *
0000:     *  THE BINARY REPRESENTATION       *
0000:     *  OF THE FRACTIONAL PART OF       *
0000:     *  E (OR ANY OTHER NUMBER          *
0000:     *  TO BE CONVERTED TO DECIMAL)     *
0000:     *  IS STORED IN LOCATIONS $800     *
0000:     *  (MOST SIGNIFICANT) TO $3FFF     *
0000:     *  (LEAST).  THE SUBROUTINES       *
0000:     *  INIT AND MULT RESIDE IN THE     *
0000:     *  $4000 PAGE OF MEMORY AND        *
0000:     *  USE TABLES PRODLO AND           *
0000:     *  PRODHI IN THE $4100 AND         *
0000:     *  $4200 PAGES RESPECTIVELY.       *
0000:     *  LOMEM MUST BE SET TO $4300      *
0000:     *  (17152 DECIMAL) OR GREATER      *
0000:     *  FROM BASIC.                     *
0000:     *                                  *
0000:     ************************************
0000:     *                                  *
0000:     *  SUBROUTINE INIT MUST BE         *
0000:     *  CALLED ONCE TO GENERATE         *
0000:     *  'MULTIPLY BY 100' TABLES        *
0000:     *  PRODLO AND PRODHI.  INIT        *
0000:     *  MUST BE CALLED BEFORE MULT.     *
0000:     *                                  *
0000:     *  SUBROUTINE MULT PERFORMS        *
0000:     *  A 'MULTIPLY BY 100' ON THE      *
0000:     *  NUMBER 'E'.  IT RETURNS         *
0000:     *  THE NEXT TWO DIGITS OF THE      *
0000:     *  DECIMAL EQUIVALENT AS A         *
```

```
0000:           *  NUMBER BETWEEN 0 AND 99 IN  *
0000:           *  LOCATION 1 (WHERE BASIC     *
0000:           *  CAN PEEK IT FOR PRINTING).  *
0000:           *                              *
0000:           ********************************

0000:           XSAV    EQU  0          X-REG SAVE LOCATION.
0001:           RESULT  EQU  1          RESULT BYTE FROM MULTIPLY.
0002:           PCOUNT  EQU  2          COUNTS NUMBER OF RAM PAGES OF E.
4100:           PRODLO  EQU  $4100      LOW BYTE TABLE (100 * IDX).
4200:           PRODHI  EQU  $4200      HI BYTE TABLE (100 * IDX).
0800:           E       EQU  $800       E, BINARY FRACTION, TO $3FFF.
0038:           NUMPAG  EQU  56         56 PAGES IN 14K
003F:           LASTPAG EQU  $3F        LAST (LEAST SIGNIFICANT) PAGE OF E.
0000:           *
0000:           ***************************************************
0000:           *
----- NEXT OBJECT FILE NAME IS EPRNT.OBJ0
4000:                   ORG  $4000
4000:86 00      INIT    STX  XSAV       PRESERVE X-REG FOR INT BASIC.
4002:A9 00              LDA  #0         STARTING PRODUCT LO BYTE.
4004:AA                 TAX             STARTING PRODUCT HI BYTE.
4005:A8                 TAY             STARTING INDEX TO PRODUCT TABLES.
4006:99 00 41   PRODGEN STA  PRODLO,Y   STORE LOW BYTE OF 100 * Y.
4009:48                 PHA             PRESERVE A-REG
400A:8A                 TXA             HI BYTE OF CURRENT PRODUCT.
400B:99 00 42           STA  PRODHI,Y   STORE HI BYTE OF 100 * Y.
400E:68                 PLA             RESTORE A-REG (PRODUCT LOW BYTE).
400F:18                 CLC
4010:69 64              ADC  #100       ADD 100 FOR NEXT PRODUCT.
4012:90 01              BCC  NXTPROD
4014:E8                 INX
4015:C8         NXTPROD INY             NEXT OF 256 PRODUCTS.
4016:D0 EE              BNE  PRODGEN
4018:A6 00              LDX  XSAV       RESTORE X-REG FOR INT BASIC.
401A:60                 RTS             (RETURN
401B:           *
401B:           ***************************************************
401B:           *
401B:A9 38      MULT    LDA  #NUMPAG
401D:85 02              STA  PCOUNT     56 PAGES IN 14K.
401F:A9 3F              LDA  #LASTPAG
4021:8D 32 40           STA  MULT1+2    INIT E REFS FOR LEAST
4024:8D 38 40           STA  MULT2+2      SIGNIGICANT RAM PAGE.
4027:A0 00              LDY  #0         INIT INDEX TO E (WILL DECR TO $FF FIRST TIME)
4029:A2 00              LDX  #0         TRICK TO CLEAR RESIDUAL CARRY.
402B:18                 CLC
402C:BD 00 42   MULBYT  LDA  PRODHI,X   (4) HI PROD BYTE IS RESIDUAL CARRY.
402F:88                 DEY             (2) NEXT MORE SIGNIFICANT BYTE OF E.
4030:BE 00 08   MULT1   LDX  E,Y        (4) (GET IT)
4033:7D 00 41           ADC  PRODLO,X   (4) TIMES 100, PLUS RESIDUAL CARRY.
4036:99 00 08   MULT2   STA  E,Y        (5) RESTORE PRODUCT BYTE.
4039:98                 TYA             (2) LAST BYTE THIS PAGE?
403A:D0 F0              BNE  MULBYT     (3/2)  NO, CONTINUE.
403C:CE 32 40           DEC  MULT1+2    (6)
```

Listing 3 continued on page 402

Listing 3 continued:

```
403F:CE 38 40         DEC   MULT2+2    (6) NEXT MORE SIGNIFICANT PAGE.
4042:C6 02            DEC   PCOUNT     (5) DONE 56 PAGES?
4044:D0 E6            BNE   MULBYT     (3)   NO, CONTINUE.
4046:7D 00 42         ADC   PRODHI,X   RETRIEVE FINAL CARRY.
4049:85 01            STA   RESULT     SAVE AS TWO-DIGIT RETURNED VALUE.
404B:A6 00            LDX   XSAV       RESTORE X-REG FOR INT BASIC.
404D:60               RTS              (RETURN)

*** SUCCESSFUL ASSEMBLY: NO ERRORS
```

Listing 4: *EPRNT, a machine-language program that converts a binary number for printing as a decimal number.*

```
FORMATTER PROGRAM - APPLE INTEGER BASIC

FILE E1 IS 'E' FROM $800 TO $3FFF

FILE EPRNT.OBJ0 IS INIT AND MULT SUBRS

CAUTION: MUST SET LOMEM TO 17152!

   10 D$="": PRINT D$;"NOMON C,I,O": PRINT D$;"BLOAD E1,A$800": PRINT D$;
      "BLOAD EPRNT.OBJ0,A$4000": PRINT D$;"PR#2"
   20 INIT=16384:MULT=16411: CALL INIT:ODDEVEN=0
   30 FOR PAGE=1 TO 10: PRINT : PRINT "      E";: FOR I=1 TO 63: PRINT " "
      ;: NEXT I: PRINT "PAGE ";PAGE/10;PAGE MOD 10: PRINT
   40 FOR LINE=1 TO 60: IF PAGE>1 OR LINE>1 THEN 50: PRINT "  E=2.";: GOTO
      60
   50 PRINT "      ";
   60 FOR GROUP=1 TO 12
   70 FOR DIG=1 TO 5: GOSUB 200: NEXT DIG
   80 PRINT " ";: NEXT GROUP
   90 PRINT : IF PAGE=10 AND LINE=35 THEN 110: NEXT LINE: REM QUIT AFTER 34500
       DIGITS
  100 PRINT : PRINT : PRINT : NEXT PAGE
  110 PRINT D$;"PR#0": END : REM  TURN PRINTER OFF
  190 REM
  192 REM  SUBROTINE 200 PRINTS NEXT DIG
  194 REM
  200 IF ODDEVEN=1 THEN 220: CALL MULT
  210 PRINT PEEK (1)/10;: GOTO 230
  220 PRINT PEEK (1) MOD 10;
  230 ODDEVEN=1-ODDEVEN: RETURN
```

Text continued from page 399:
quired in order to be correct. The final page and line number were precalculated to detect this stopping point. Lines 200 thru 230 make up a digit-printing subroutine that calls the assembly-language multiply-by-100 routine (MULT) every other digit.

Analysis of the Algorithm

The specified algorithm has the property that the contents of *e* at a given stage of computation will yet be divided by ($i!$), where *i* is the current divisor. The first implication of this property is that the allocated memory need not be initialized, since it will all be reduced to insignificance when divided by $n!$ (because *n*, the starting divisor, was specifically chosen such that $n!$ is greater than the significance corresponding to that much memory).

An interesting aspect of this implication is that the result is perfect to the last calculated bit, despite the fact that terms beyond the *n*th have been omitted. Additional terms (before the *n*th) would simply cause the allocated

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Yet, on the other hand (and most puzzling) others will rant on and on and on that:

"...don't even try, it's just impossible — all those Business Loans Programs are strictly for the Chryslers, the Lockheeds, the big corporations...not for the little guy or small companies." etc.



Still there are those who declare:

"...I need money right now...and small business government loans take too darn long. It's impossible to qualify. No one ever gets one of those loans."

Or you may hear these comments:

"...My accountant's junior assistant says he thinks it might be a waste of my time!" "Heck, there's too much worriesome paperwork and red tape to wade through!"

Frankly — such rantings and ravings are just a lot of "bull" without any real basis — and only serve to clearly show that lack of knowledge...misinformation...and and not quite fully understanding the UNITED STATES GOVERNMENT'S Small Business Administration's (SBA) Programs have unfortunately caused a lot of people to ignore what is without a doubt — not only the most important and generous source of financing for new business start ups and existing business expansions in this country — but of the entire world!

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- **Red tape comes about only when the loan application is sent back due to applicant not providing the requested information...or providing the wrong information**
- **The SBA is required by Congress to provide a minimum dollar amount in business loans each fiscal year in order to lawfully comply with strict quotas. (Almost 5 billion this year)**

Yet, despite the millions who miss out — there are still literally thousands of ambitious **men and women nationwide** who are properly applying — being approved — and **obtaining sufficient funds** to either start a new business, a franchise, or buy out or expand an existing one. Mostly, they are all just typical Americans with no fancy titles, who used essentially the **same effective know-how** to fill out their applications that you'll find in the Money Raiser's Guaranteed and Direct Loans Manual.

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memory to have different contents (ie: be initialized arbitrarily) when the nth term is reached. Since division proceeds from high toward low significant bits, arbitrary data beyond a specified least significant byte can never affect the contents of that byte or any more significant byte. There can be no accumulated truncation errors such as those encountered with summation-of-terms approaches.

The second implication is that, at a given stage of calculation, only the most significant bytes of e (ie: those that will not subsequently be divided to insignificance) need to be divided! The first divisions can be very short, only a few bytes or so, while the last ones must encompass all of e. For a given divisor, i, the number of (least significant) bytes of e which need *not* be divided is $\log_{256}(i!)$, which may be calculated by the HP-41C program in listing 5. Note that it calls the previously written program FACTLOG, which calculates the number of digits of ($i!$). The algorithm used is:

$$\text{number of bytes of } i! = \text{number of digits of } i!/\log_{10}(256)$$

It is unfeasible to precalculate the number of bytes to leave undivided (or the number to divide) for each divisor and to save it in a table because the table would consume a great deal of memory. As an alternative, the divisors can be broken into blocks of, say, 1 K bytes each, and for each block a fixed number of bytes (of e) can be divided. The number of bytes to divide for a given block is calculated as the total number of bytes in the e array minus the number of insignificant bytes (calculated as above) corresponding to the minimum divisor of the block, plus a "guard" byte or two to cover slight calculation errors.

In a later program that calculated e to 116,000 digits, I used 47 K bytes (188 pages of 256 bytes each) of memory, and the maximum divisor was 28,800. The divisors were grouped into fifteen blocks of 2 K-byte divisors each, and the number of memory pages not to be divided were precalculated for each block (see table 3). This version of the program used a lookup table to determine how many pages to divide (188 minus the number *not* to divide) for each divisor. This technique proved extremely beneficial because it reduced the computation time from four days to two.

The 47 K-byte version used virtually all the memory in a 48 K-byte Apple. The e array occupied hexadecimal locations 400 thru BFFF. A starting divisor of 28,800

Listing 5: *The FACTBYT program for the Hewlett-Packard HP-41C calculator. This program calculates the precision to which the multibyte division has to be carried out for a given divisor. See table 3 for details.*

```
LBL ALPHA FACTBYT ALPHA XEQ ALPHA FACTLOG ALPHA
256 LOG / RTN
```

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Range of Divisors in Same Group	Number of Insignificant Bytes	Number of Pages That Can Be Left Uncalculated
2 to 2047	0	0
2048 to 4905	2448	9.6
4096 to 6143	5406	21.1
6144 to 8191	8558	33.4
8192 to 10239	11836	46.2
10240 to 12287	15206	59.4
12288 to 14335	18652	72.9
14336 to 16383	22158	86.6
16384 to 18431	25718	100.5
18432 to 20479	29325	114.5
20480 to 22527	32972	128.8
22528 to 24575	36656	143.2
24576 to 26623	40374	157.7
26624 to 28671	44123	172.4
28672 to 30719	47900	187.1

Table 3: *Table of truncated multibyte divisions that can be made during the second algorithm. Due to the nature of the second algorithm, most divisors need not carry the division out the entire length of the multibyte dividend. By grouping divisors and not calculating the bytes that are unimportant to that particular group, calculation time can be significantly decreased.*

resulted in 115,925 digits of precision. Because the result occupied screen memory, it had to be written to cassette tape by the calculation program before returning to the Apple II monitor. Because there was no memory available for a BASIC program, the output formatting program was coded in assembly language and resided in parts of pages 0 and 1. Pages 2 and 3 were used for the multiply-by-100 tables.

On the Horizon

As with any limitless search, there remains the challenge to compute *e* to even greater precision. Unfortunately, the computation time of the specified algorithm is exponentially related to the precision sought. Divide operations on high-speed computers (approximately 12 μs per 32 bits) are two orders of magnitude faster than the 6502 routines. The ultimate approach is to construct a custom "divide machine." Current technologies and low programmable memory prices make it feasible to construct such a machine with a thousand-fold performance improvement over the 6502 microprocessor. With such a machine, *e* could be computed to 100,000,000 digits within a couple of years (one year constructing and testing, one year computing). Such a machine would require power supply backup and error-correcting memory. The memory should be purchased at the latest possible date due to decreasing prices.

Once a few simple concepts are understood, the computation that I have described is as easy as *pi* (see listing 6). Why do people spend time computing these numbers to such absurd precision? Because they're there, I suppose. Who knows what great discoveries will be made by personal computer owners in the coming years? Rest assured that a guaranteed place in the mathematics Hall of Fame awaits the discoverer of the next greatest prime number. ■

Listing 6: *A partial printout of the value of e. The first line agrees with the fifty-place value for e that is given in the* CRC Standard Mathematical Tables.

```
     E                                                                    PAGE 01

E=2.71828 18284 59045 23536 02874 71352 66249 77572 47093 69995 95749 66967
    62772 40766 30353 54759 45713 82178 52516 64274 27466 39193 20030 59921
    81741 35966 29043 57290 03342 95260 59563 07381 32328 62794 34907 63233
    82988 07531 95251 01901 15738 34187 93070 21540 89149 93488 41675 09244
    76146 06680 82264 80016 84774 11853 74234 54424 37107 53907 77449 92069
    55170 27618 38606 26133 13845 83000 75204 49338 26560 29760 67371 13200
    70932 87091 27443 74704 72306 96977 20931 01416 92836 81902 55151 08657
    46377 21112 52389 78442 50569 53696 77078 54499 69967 94686 44549 05987
    93163 68892 30098 79312 77361 78215 42499 92295 76351 48220 82698 95193
    66803 31825 28869 39849 64651 05820 93923 98294 88793 32036 25094 43117
    30123 81970 68416 14039 70198 37679 32068 32823 76464 80429 53118 02328
    78250 98194 55815 30175 67173 61332 06981 12509 96181 88159 30416 90351
    59888 85193 45807 27386 67385 89422 87922 84998 92086 80582 57492 79610
    48419 84443 63463 24496 84875 60233 62482 70419 78623 20900 21609 90235
    30436 99418 49146 31409 34317 38143 64054 62531 52096 18369 08887 07016
    76839 64243 78140 59271 45635 49061 30310 72085 10383 75051 01157 47704
    17189 86106 87396 96552 12671 54688 95703 50354 02123 40784 98193 34321
    06817 01210 05627 88023 51930 33224 74501 58539 04730 41995 77770 93503
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    69829 46959 30801 91529 87211 72556 34754 63964 47910 14590 40905 86298

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    92105 78191 37103 01889 79206 40888 39747 67667 14472 73142 54467 92350
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    28065 19535 45205 31735 36808 95458 99021 80783 14577 58912 80203 97005
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Circle 213 on inquiry card.

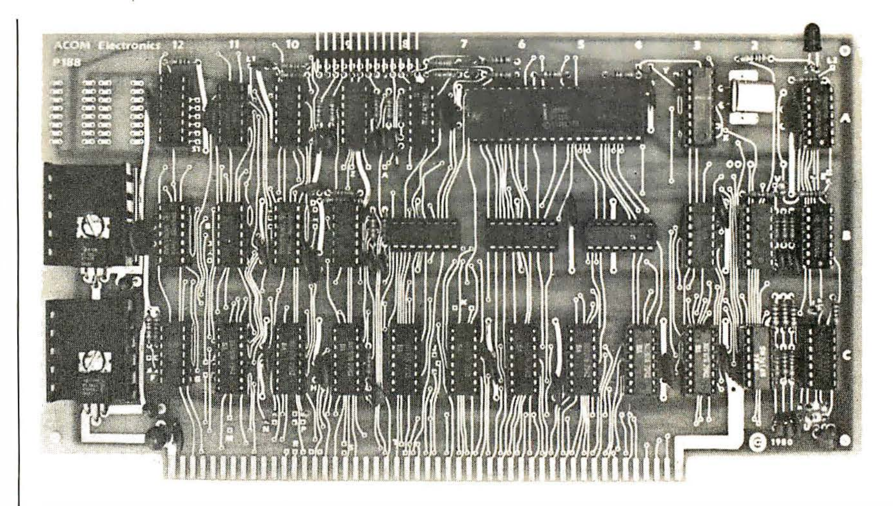
CCS Microcomputer Systems

A new line of S-100 Z80-based microcomputer systems from California Computer Systems provides real-time hardware-vectored interrupt and interrupt-nesting capabilties. Multiprocessing with interleaved data-transfer rates of up to 2 megabytes per second can be achieved using direct memory access. The main board has two programmable real-time clocks, two 8-bit parallel interface channels, and two programmable RS-232C serial I/O (input/output) channels, one of which may be used for synchronous communication. The chassis contains a nineteen-slot motherboard and a power supply.

The CCS OASIS multitasking operating system features reentrant and relocatable program capabilities, and employs an ISAM (indexed-sequential access method) file structure. Task-to-task communication, file protection, timekeeping, spooling, overlay, and device-independent I/O are accomplished through software. The operating system is supported with debug, editing, relocatable-linkage, and file-sort utilities. CP/M and MP/M can be used with the system. A BASIC interpreter and compiler, FORTRAN, COBOL, and Pascal compilers are also available.

Optional boards include printer and terminal interfaces, 16 K-, 32 K-, and 64 K-byte memory boards, floppy-disk subsystems and expansions, and Winchester-type disk subsystems and expansions. Prices for the CCS systems range up to $9100. Contact California Computer Systems, Marketing Department, 250 Caribbean Dr, Sunnyvale CA 94086, (408) 734-5811.

Circle 524 on inquiry card.



Acom's 8088 Board

The P188 is an S-100 bus 8088 microprocessor board that will run as a stand-alone processor or as a slave. Jumpers allow configuring the card to run in different operating modes, as well as with static or dynamic memory. The 8088 microprocessor has 16-bit internal architecture, addresses 1 megabyte of memory, and features 8- and 16-bit signed and unsigned arithmetic in binary or decimal, including multiply and divide.

The P188 costs $345 assembled and tested, and $275 in kit form. For more information, contact Acom Electronics, 4151 Middlefield Rd, Palo Alto CA 94303, (415) 494-7499.

Circle 525 on inquiry card.

Single-Board 6800 Computer

The ACS 12-PRO requires a power supply and terminal to operate. The 6800-based system provides two programmable 16-bit timers, an RS-232C serial port, two 8-bit parallel ports with handshake control, and up to 4 K bytes of programmable memory and 6 K bytes of PROM (programmable read-only memory).

The ACS 12-PRO is supplied with Datricon's 4 K D-FORTH operating system. With 1 K bytes of programmable memory, D-FORTH, and a manual, the ACS 12-PRO sells for $495. For additional details, contact Datricon Corporation, 7911 NE 33rd Dr, Suite 200, Portland OR 97211, (503) 284-8277.

Circle 526 on inquiry card.

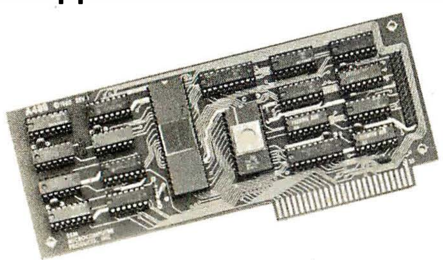
Where Do New Products Items Come From?

The information printed in the new products pages of BYTE is obtained from "new product" or "press release" copy sent by the promoters of new products. If in our judgment the information might be of interest to the personal computing experimenters and homebrewers who read BYTE, we print it in some form. We openly solicit releases and photos from manufacturers and suppliers to this marketplace. The information is printed more or less as a first-in first-out queue, subject to occasional priority modifications. While we would not knowingly print untrue or inaccurate data, or data from unreliable companies, our capacity to evaluate the products and companies appearing in the "What's New?" feature is necessarily limited. We therefore cannot be responsible for product quality or company performance.

What's New?

PERIPHERALS

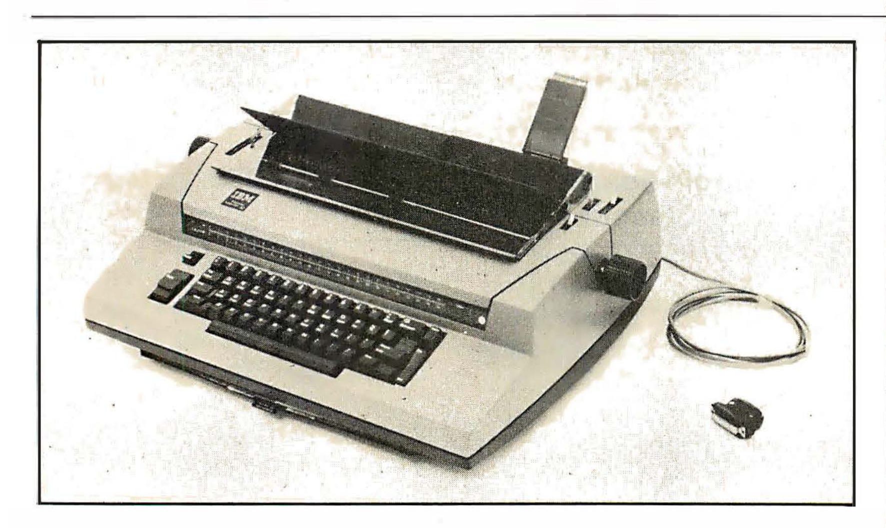
Apple IEEE-488 Interface



The A488 interface card permits the Apple II and the Apple II Plus to operate as IEEE-488 bus controllers. The A488 uses an MC68488 LSI 488-controller integrated circuit that decreases the number of circuits required. The board has 2 K bytes of firmware in EPROM (erasable programmable read-only memory). For special-purpose firmware development, the EPROM can be replaced by programmable memory. The A488 allows bus and system control with character-string instrument commands for set-up, measure, clear, local, trigger, serial-poll, and respond functions. Any equipment on the bus can be designated by a name of up to sixteen characters. Up to fifteen pieces of equipment can be connected to the A488 across a distance of up to 20 meters (66 feet) from the Apple. The card's driver firmware is linked to string routines within Applesoft; floating-point processing of numeric data is easily done. Error checking is included, and software timing loops are not needed.

The A488 is priced at $475 from SSM Microcomputer Products Inc, 2190 Paragon Dr, San Jose CA 95131, (408) 946-7400.

Circle 527 on inquiry card.



Turn IBM Typewriters Into RS-232Cs

California Micro Computer's 5060 and 5061 modules enable the IBM Model 50, 60, and 75 electronic typewriters to perform as RS-232C-compatible computer I/O (input/output) devices. The modules can be installed and removed easily without requiring modifications to the typewriter. The model 5061 is a print-only version, while the 5060 allows the typewriter to perform full terminal functions. Both units offer ASCII coding with full buffering. The 5061 costs $497 and the 5060 is $860.

For further information, contact California Micro Computer, 9323 Warbler Ave, Fountain Valley CA 92708, (714) 968-0890.

Circle 528 on inquiry card.

Printer for Under $1000

The Model 445 Paper Tiger printer features a seven-wire ballistic-type print head and tractor-feed motor drives. The 445 can print at speeds up to 198 cps (characters per second). Functions include bold text and the ability to print 80 columns at 10 pitch and 132 columns at 16.7 pitch. Other features include the 96-character upper- and lowercase ASCII (American Standard Code for Information Interchange) character set, six or eight lines-per-inch vertical spacing, multiline buffering, and RS-232C- and Centronics-compatible parallel interfaces. Transmission rates from 110 to 1200 bps (bits per second) are selectable. Variable form length, perforation skipping, and the ability to handle six-part forms and roll paper are other features.

Integral Data Systems' DotPlot graphics capability is offered as an option. DotPlot enables printing the full range of graphics characters. The Paper Tiger Model 445 costs $795 and the DotPlot package is $99. Contact Integral Data Systems Inc, Milford NH 03055, (603) 673-9100.

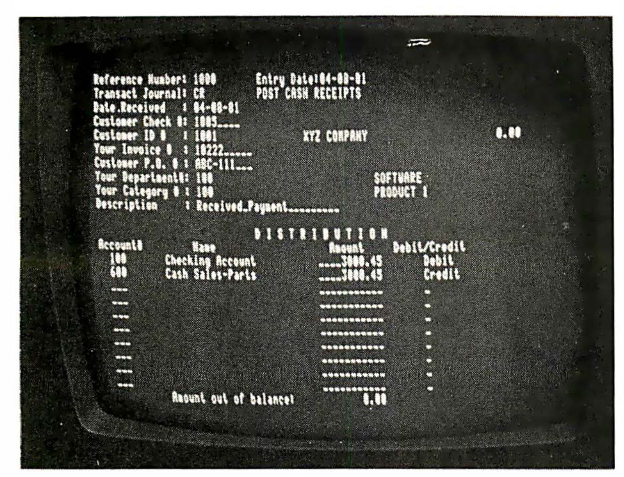
Circle 529 on inquiry card.

Extend the TRS-80 Color Computer Bus

The Color Connection is a device that extends the TRS-80 Color Computer system bus as a System-50 bus (SS-50). Using the Color Connection, floppy-disk drives and video terminals can be added, and the Color Computer's 16 K-byte internal memory can be expanded. The Color Connection sells for $99.95 from Percom Data Company, 211 N Kirby, Garland TX 75042, (800) 527-1592; in Texas, (214) 272-3421. Circle 530 on inquiry card.

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What's New?

PERIPHERALS

Low-Cost Color-Graphics Terminal



RCA's VP-3301 is a microprocessor-controlled terminal with color graphics, reverse video, programmable and resident character sets, selectable data rates and formats, a flexible-membrane keyboard, and audio feedback. The VP-3301 can be connected to modems for communication with most timesharing and data-base computer networks. The software-selectable character-display format can produce either 40 characters by 24 lines or 20 characters by 12 lines. Characters and background can be displayed in one of eight colors or gray scales. The communications interface is RS-232C or 20 mA current-loop. Configuration control includes line/local, uppercase only, full- and half-duplex, data-word formatting, plus two control-code options. The video output can be directly connected to monitors or, with an RF (radio frequency) modulator, to a television set. The suggested price for the VP-3301 is $369 from RCA Microcomputer Products, New Holland Ave, Lancaster PA 17604, (717) 397-7661.

Circle 531 on inquiry card.

8-Inch Floppy-Disk Drives

Matchless Systems, 18444 S Broadway, Gardena CA 90248, (213) 327-1010, has announced the MS-800 8-inch floppy-disk drive. The drive is compatible with the TRS-80 Models I and II, the Apple II, and S-100 systems. The MS-800 has a capacity of 256 K bytes of storage. The data transfer rate is 256 k bps (bits per second) and the track-to-track access time is 10 ms. The prices range from $995 to $1595, which includes all hardware (such as the controller), software, and documentation. Circle 532 on inquiry card.

S-100 I/O Board

The MFIO is an I/O (input/output) board designed for S-100 bus systems. It features four serial RS-232C ports with independent data rates of 50 to 19.2 k bps. It also includes 24 bits of parallel I/O configurable for four ports, five timer/counters, sixteen levels of vectored-interrupt control, and an optional battery-powered real-time clock/calendar. The MFIO costs $595. For more information, contact Digicomp Research, Terrace Hill, Ithaca NY 14850, (607) 273-5900.

Circle 533 on inquiry card.

Series 47-TR Plotter

The Series 47-TR Strip Chart/Plotter is a curve tracer with alphanumeric capabilities. Its plotting area is 25 cm (10 inches) wide. The plotter features an RS-232C- or IEEE-488-compatible port and bidirectional paper drive. It requires two 8-bit words formatted to provide analog pen position. Pen speed is 75 cm per second with a position accuracy of $\pm 0.15\%$, full scale. Paper can be incremented up to 2 cm per second at 0.0127 cm per step. The 47-TR is priced at $945. For details, contact Pedersen Instruments, 2772 Camino Diablo, Walnut Creek CA 94596, (415) 937-3630.

Circle 534 on inquiry card.

Graphics Terminal for the North Star

The Sigma 1042S high-resolution, memory-mapped graphics terminal is designed for the North Star microcomputer. The display provides a 640 by 800 dot matrix backed by a 64 K-byte display memory. The display memory is divided into sixteen 4 K-byte blocks, which are individually selectable for mapping onto a main-memory window of only 4 K bytes. The 1042S terminal can also be used as a word-processing work station. In this application mode, it includes variable spacing, multiple fonts, and scientific-character capabilities. Reverse video, blinking, and intensification are offered as hardware features. The terminal can be used as a system console under CP/M. The 1042S costs $4000.

For more information, contact Sigma Information Systems USA Inc, 556 Trapelo Rd, Belmont MA 02178, (617) 484-2063.

Circle 535 on inquiry card.

Cash Register Scans Bar Code

The CE-1000 bar-code-scanning cash register can keep track of your entire inventory. It is designed for use with the Commodore CBM microcomputer and includes software, firmware, and hardware. The unit can read UPC (Universal Product Code) bar codes found on most products for point-of-sale operations, making it useful for convenience, liquor, food, record stores, and other small businesses.

The CE-1000 bar-code scanner costs $1350. For more information, contact Creative Equipment, 50 NW 68 Ave, Miami FL 33126, (305) 261-7866.

Circle 536 on inquiry card.

PUBLICATIONS

The Sizzle Sheet

The Sizzle Sheet is a marketing-communications guide for those who market computers, communications and information products, systems, and services. Featured are reviews and reports, editorials on the news, business and trade press, plus special issues.

For details, contact **The Sizzle Sheet**, POB 801, 150 Speen St, Framingham MA 01701, (617) 875-0013.

Circle 537 on inquiry card.

Symbol Manipulation Using LISP

This is a manual for the LISP programming language. The book introduces the basics of LISP programming and demonstrates how it is used in practice. It also discusses how artificial intelligence systems are built. Case studies and problems in pattern matching, natural-language understanding, and problem solving are included. An appendix offers a sample terminal session, lists basic LISP functions, and explains differences between MACLISP and INTERLISP.

Symbol Manipulation Using LISP costs $13.95, and is published by Addison-Wesley, Reading MA 01867, (617) 944-3700.

Circle 538 on inquiry card.

Printronix Printers Described in Brochure

A color brochure describing Printronix dot-matrix printers is available from Printronix Inc. The brochure discusses the Printronix hammer-bank printing mechanism and includes examples of graphics, bar codes, labels, and alphanumeric forms. For your free copy, contact Printronix Inc, 17421 Derian Ave, POB 19559, Irvine CA 92713, (714) 549-7700.

Circle 539 on inquiry card.

Magazine for TI 99/4 Users

99'er Magazine is a bimonthly magazine with news about the TI 99/4 and other TMS9900-based personal-computer systems. It features tutorial articles, software, book and product reviews, opinions and news items, and a question-and-answer technical forum.

Each issue is divided into sections for education, games and simulations, home activities, and business, scientific, or professional applications. Regular features include columns on the Logo language, CAI (computer-aided instruction), speech-synthesis usage, interfacing with peripherals, computer chess, The Source and TEXNET, news from user groups, and lessons in programming techniques. Advertisements from suppliers of software, peripherals, and other related products and services are also included. A bulletin-board page for noncommercial messages is provided for its readers.

The subscription rate is $15 for one year. Contact **99'er Magazine**, Emerald Valley Publishing Company, 2715 Terrace View Dr, Eugene OR 97405, (503) 485-8796. Circle 540 on inquiry card.

GamesMaster Catalog

The GamesMaster Catalog has listings of board, computer, electronic, hand-held, fantasy, and other kinds of games. One section is exclusively devoted to Dungeons and Dragons-type games. Nearly 1000 games are described in full detail, including landscape sets and miniature pieces.

For a copy of the catalog, contact Boynton & Associates Inc, Clifton House, Clifton VA 22024, (703) 830-1000.

Circle 541 on inquiry card.

Computer Crimes Books

The Computer/Law Journal has published a two-volume set on computer crimes. This first volume contains an introduction by Senator Abraham Ribicoff, author of the Federal Computer Crimes Protection Act. There are articles by well-known scholars like Donn Parker, Susan Nycum, John Taber, Rob Kling, and Jay Becker.

Volume two has a history of the Stanley Mark Rifkin case and a compliation and analysis of all federal and state statues and bills addressing computer crimes, as well as a case digest, bibliography, and book reviews. Both issues are available for $16 each, plus $1 per issue postage. Contact the Center for Computer/Law, 530 W 6th St, 10th floor, Los Angeles CA 90014.

Circle 542 on inquiry card.

Computer Books from Entelek

This catalog of computer books from Entelek features books on programming languages, microcomputers, robots, calculators, and educational uses of computers. The catalog is free from Entelek, Ward-Whidden House/The Hill, POB 1303, Portsmouth NH 03801.

Circle 543 on inquiry card.

1981 Computer-Science and Engineering Books

A catalog of MIT Press books in the computer-science and engineering fields is available. This catalog describes over fifty books. Most of the books are offered at a 20% discount through December 1981. Copies of the catalog can be obtained from The MIT Press, Promotion Department, 28 Carleton St, Cambridge MA 02142, (617) 253-5642.

Circle 544 on inquiry card.

What's New?

SOFTWARE

Merge Your 737 Printer and Scripsit

Until Apparat Inc introduced Flextext, TRS-80 Model I users could not use all of the features of the Centronics 737 printer (Radio Shack Line Printer IV) with Scripsit, Radio Shack's word-processing program. Flextext is a utility for Scripsit and the 737 printer that supports proportional or compressed character sets in normal and extended modes, right-justified formatting using the proportional or compressed character sets, underlining in any of the Scripsit-selectable formats and Flextext-selectable character sets, super- or subscripts, and the intermixing and combining of the 737's features anywhere in a document. Flextext requires at least one disk drive and a TRSDOS-type operating sytem. The program costs $29.95 from Apparat Inc, 4401 S Tamarac, Denver CO 80237.

Circle 545 on inquiry card.

Chinese Lessons Program

Chinese greetings, times, seasons, numbers, foods, and other commonly used terms are contained in eleven computer-instruction lessons. Color, graphics, and sound are used in each lesson. Memory aids, meanings, and pronunciations are presented with the Chinese characters. The proper stroke sequence for each character is shown and can be repeated at the user's pace.

The Chinese lesson program is available for $29.95 on a double-sided 5-inch floppy disk for the Apple II with 48 K bytes of programmable memory and a single disk drive. For details, contact Computer Translation Inc, Department BPI, POB 7004 University Sta, Provo UT 84602, (801) 224-1169. Circle 546 on inquiry card.

Utilities for the TRS-80 Color Computer

Mint Software's utilities for the Color Computer require 16 K bytes of memory. There are three cassette-based programming utilities available: Renumber, which provides the capability to load a program, renumber and save it; Squeeze, which will compress BASIC code to utilize minimum memory; and Merge, which allows two separate programs on cassette to be merged and saved. Other aids for cross-referencing line numbers and variables are available. The programs cost $19.95. A 16 K-byte memory expansion is also available for $70. Contact Mint Software, 6422 Peggy St, Baton Rouge LA 70808, (504) 766-2318.

Circle 547 on inquiry card.

DMADOS for 8080/Z80 Systems

DMADOS is a single-user, CP/M-compatible 8080 and Z80 disk operating system. It maintains up to sixteen user-defined passwords, allows files to be declared write-protected or invisible to the directory, and can function as a batched console processor. Using DMADOS, up to six print files can be sent to a background print task for printing. User-oriented prompting and error messages are provided.

DMADOS offers support for floppy- and hard-disk files of up to 4.2 megabytes. It is supplied with several utilities and a manual. DMADOS is available on 8-inch floppy disks or North Star double/quad-density formats. For more information on this $200 operating system, contact John D Owens Associates Inc, 12 Schubert St, Staten Island NY 10305, (212) 448-6283.

Circle 548 on inquiry card.

Electronics Designers Program

Wiremaster is for small electronics companies with printed-circuit layout and wrapped-wire prototyping production problems. Connection data is derived from the schematic diagram and fed to Wiremaster in a CP/M text file. Outputs include a network map showing all pins and wires, a wire list sorted by lengths and levels, a parts list, and checklists that detect all wiring errors. The resulting information can then be used for printed-circuit-board layout, error checking, wiring, component stuffing, and system debugging.

Wiremaster comes on a single-density 8-inch CP/M floppy disk with a manual for $150. It runs on Z80 and TRS-80 Model II CP/M systems with 48 K bytes of memory. Contact Afterthought Engineering, 7266 Courtney Dr, San Diego CA 92111, (714) 277-7863.

Circle 549 on inquiry card.

Dragonquest

In a race against the sun, you search for Smaegor, Monarch of Dragonfolk, who has kidnapped the Princess of the Realm and holds her in an unknown place. You must search the land, seeking the tools needed for the ultimate battle. On the river Delta and in the Temple of Baathteski, clues abound. But where is the Princess? This is the scenario of Dragonquest, an adventure game from The Programmer's Guild, POB 66, Peterborough NH 03458, (603) 924-6065. It runs on TRS-80 Model I microcomputers, and costs $15.95 on cassette or $21.95 on a floppy disk.

Circle 550 on inquiry card.

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C. ITOH Starwriter, 25 cps, daisy wheel	**$1575**
C. ITOH Starwriter, 45 cps, daisy wheel	**$1849**
EPSON MX-80, 80 cps, 9x9 dot matrix	**$545**
ANADEX 9500/9501, up to 200 cps, high resolution dot	**$1349**
OKIDATA Microline 80, 80 cps, 9x7 dot matrix	**$525**
Microline 82, bidirectional, friction/pin feed	**$625**
Microline 83, bidirectional, 120 cps, uses 15" paper	**$995**
TI-810, 150 cps, Basic	**$1695**
Package-Compressed print, vertical form control	**$1830**
CENTRONICS 704-9,180 cps, 9x9 dot matrix, 132 col, RS-232	**$1595**
704-11,180 cps, 9x9 dot matrix, 132 col, parallel	**$1695**
730,100 cps, 7x7 dot matrix, same as R.S. LPII	**$660**
737,80 cps, nx9 dot matrix, same as R.S. LPIV proportional spacing	**$849**
DEC LA-34	**$1085**

S-100 SPECIALTIES

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		list	only
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2065C	64K dynamic RAM/Bank Select	$720	$580
2810A	Z-80 CPU, serial port, ROM monitor	$310	$259
2422A	Floppy Cont, CP/M 2.2, ROM monitor	$425	$345
SSM	**CB2 Z-80 CPU**	$344	$295
	2P + 2S I/O interface	$290	$249

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POWER 1, power supply for 2 8" drives	**$135**
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controller, CDC Hawk Drive (5 fix, 5 rem)	$6995	$5995
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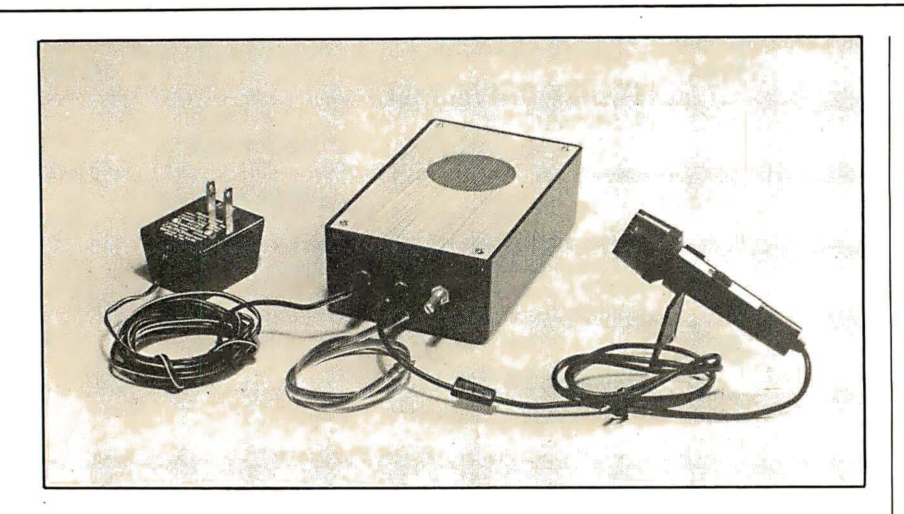
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MISCELLANEOUS



Voice Recognition for Z80 Systems

The Cognivox Model VIO-232 voice peripheral is designed for microcomputers using the Z80 microprocessor with a minimum-size programmable memory of 16 K bytes. The VIO-232 can be programmed to recognize words or short phrases from up to 32 entries, and it can answer with up to 32 words or short phrases. The recognition and voice response vocabularies can be different, allowing a dialogue with the computer. Vocabularies larger than 32 words are possible. The Cognivox VIO-232 includes a microphone, power supply, amplifier, speaker, and manual. The price is $149 from Voicetek, POB 388, Goleta CA 93116.

Circle 551 on inquiry card.

RS-232C-to-Current-Loop Adapter

The ADA400 is a bidirectional RS-232C-to-current-loop adapter, ideal for use with KIM-1 microcomputers. It allows the utilization of an RS-232C-interface terminal instead of a current-loop-interface teletypewriter. The ADA400 does not alter the data-transfer rate. It uses standard power supplies with low current requirements. The adapter can be modified to become an RS-232C-to-TTL (transistor-transistor logic) and TTL-to-RS-232C adapter. The ADA400 retails for $24.50. More information can be obtained from Connecticut microComputer Inc, 34 Del Mar Dr, Brookfield CT 06804, (203) 775-4595.

Circle 552 on inquiry card.

Record-Retrieval System for PL/I-80

BT-80 is a single-user record-retrieval system based on the B-tree index-organization technique. BT-80 is useful in PL/I-80 applications where single- or multi-keyed access to data records is required. Its facilities can be accessed from PL/I-80 or assembly-language application programs. The system includes utilities that provide access to command-level functions.

BT-80 runs under the CP/M 2.0, MP/M, and CP/NET operating systems. To operate, BT-80 requires the PL/I-80 run-time library and LINK-80 linkage editor. For complete details, contact Digital Research, POB 579, 801 Lighthouse Ave, Pacific Grove CA 93950, (408) 649-3896. Circle 553 on inquiry card.

Battery Backup for the PET

Backpack is a battery backup system for the Commodore PET. It is designed for installation within the computer case. Backpack provides 6 to 10 minutes of full-power emergency backup to the computer (video display included) during power failures. The batteries are recharged from the computer's power supply. No special wiring is needed to install the device. Backpack comes assembled for $225.

For more information, contact ETC Corporation, POB G, Apex NC 27502, (919) 362-4200.

Circle 554 on inquiry card.

Datapro Rates Word-Processing Systems

Thirteen word-processing systems have been named to the 1980 Datapro Honor Roll. Selection of these systems was based on results of a mail survey, which is contained in a thirty-page report, *Word Processing Systems User Ratings*. This report also contains general information about word-processing systems. The report is available for $15 from Datapro Research Corporation, 1805 Underwood Blvd, Delran NJ 08075, (609) 764-0100.

Circle 555 on inquiry card.

Floppy-Disk Carrier Case

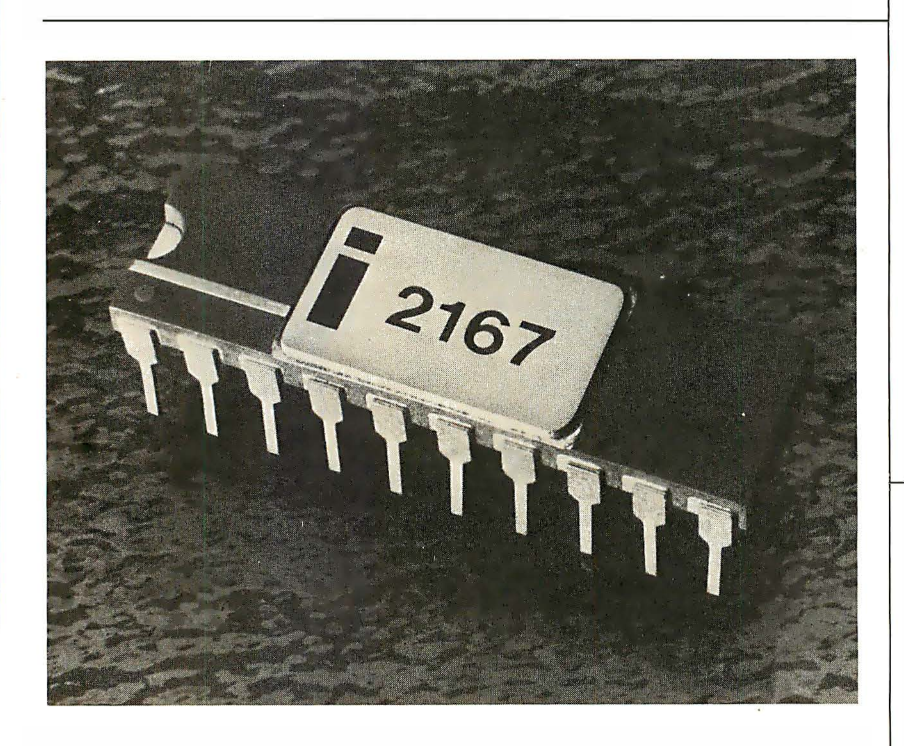
The En Route case carries up to fifty 8- and 5-inch floppy disks during travel. It is small enough to fit under an airplane seat. The case has a polyethylene inner lining to prevent dust buildup. A key lock is included. The En Route case costs $65 from Inmac, 2465 Augustine Dr, POB 4780, Santa Clara CA 95051, (408) 727-1970.

Circle 556 on inquiry card.

Universal Development System

The UDS-1000 universal development system is a floppy-disk-based system that uses the Z80 microprocessor. Various cross-assemblers for software development are supplied from a selection including the Texas Instruments TMS1000 and the TMS-1400 series; Rockwell R6500/1, MM75, -76, -77, and -78 series; Motorola 6800; Mostek 3870; Intel 8748, 8048; RCA 1802; NSC COP 420; OKI OLMS42; and other microprocessors. In addition to the cross-assembler, a ROM (read-only memory) emulation board for prototype testing and an EPROM (erasable programmable ROM) programmer are included. The price of the system, including 64 K bytes of programmable memory, a 24-line by 80-character video terminal, an 80 cps (characters per second) printer, ROM emulation, and the EPROM programmer board, is $8750. For information, contact Multitech Electronics Inc, 10322A N Stelling Rd, Cupertino CA 95014, (408) 252-4212.

Circle 557 on inquiry card.



16 K by 1-Bit Static Memory

The 2167 is a 16 K by 1-bit programmable static memory device from Intel. The 2167 can replace Intel's 2147 and 2141 static circuits. Compared to these devices, the 2167 has a greater density and lower power consumption. It also has a 55 ns access speed. The HMOS (high-performance metal-oxide semiconductor) device does not require clocking or timing strobes. The 2167's inputs and outputs are TTL-compatible and are unlatched. Address setup and hold timings are not required.

Prices for the 2167 are $68.55 per unit, in quantities of 100. For further details, contact Intel Corporation, 3585 SW 198th Ave, Aloha OR 97005, (503) 642-6344.

Circle 558 on inquiry card.

Spelling Error Detection/Correction Package

Proof/it is a set of programs that scans the words in a text file and compares them with those in one or more dictionaries. Words that are not found are flagged as possible errors. Correctly spelled new words can be added automatically to the dictionary. Corrections can be directly substituted for incorrectly spelled words in the text file. A package including manual and software on a floppy disk with over 10,000 words in the dictionary is $125. Software on a 5-megabyte hard-disk pack with over 30,000 words in the dictionary is $100 more. The manual can be purchased separately for $10.

Proof/it runs on Alpha Micro AM-100 computers with 32 K bytes of memory. For information, contact Datalab Inc, 617 E University, Suite 250, Ann Arbor MI 48104, (313) 995-0663.

Circle 559 on inquiry card.

Daisy-Wheel Printer

The Starwriter letter-quality daisy-wheel printer runs at 25 cps. The Starwriter comes with a Centronics-compatible parallel interface, and uses Diablo ribbons and print wheels. The Starwriter has graphics capabilities and is code-compatible with Qume and Diablo printers. The printer accommodates paper widths of up to 38 cm (15 inches), and can make three copies. The Starwriter is available for $1779 from Computer Textile Inc, 10960 Wilshire Blvd, Suite 1504, Los Angeles CA 90024, (213) 477-2196.

Circle 560 on inquiry card.

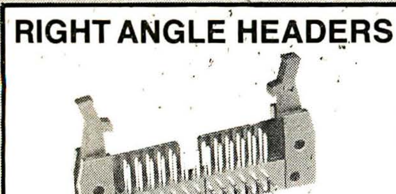
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40	IDE40	5.65
50	IDE50	5.90

RIBBON CABLE



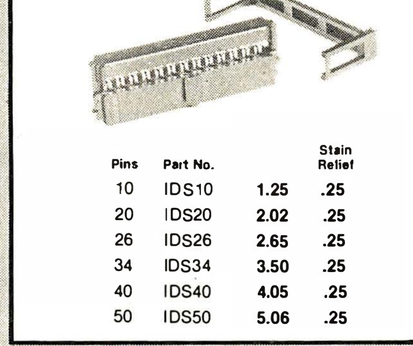
Conductors	Solid Color 10 ft.	Solid Color 100 ft.	Color Coded 10 ft.	Color Coded 100 ft.
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14	3.40	23.80	5.00	42.00
16	3.70	27.20	5.60	48.00
20	4.40	34.00	7.00	60.00
24	5.00	40.80	8.00	72.00
26	5.40	44.20	8.60	78.00
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40	7.80	68.00	13.00	120.00
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Hood	DB25C	1.10
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Hood	IDC25C	1.35

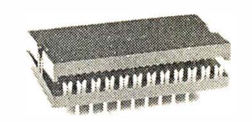
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Pins	Part No.		Stain Relief
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20	IDS20	2.02	.25
26	IDS26	2.65	.25
34	IDS34	3.50	.25
40	IDS40	4.05	.25
50	IDS50	5.06	.25

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16	IDP16	1.40
24	IDP24	2.25
40	IDP40	3.65

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3.5"	1.37	4.15	7.37	7.5"	2.08	7.07	13.09
4.0"	1.42	4.44	7.94	8.0"	2.14	7.38	13.73
4.5"	1.48	4.74	8.54	8.5"	2.18	7.69	14.36
5.0"	1.54	5.04	9.13	9.0"	2.24	8.11	15.01
5.5"	1.58	5.38	9.72	9.5"	2.30	8.32	15.65
6.0"	1.65	5.66	10.31	10.0"	2.39	8.71	16.28

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500	3½"	250	6"
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250	4½"	100	7"

Kit No. 3	$32.95		
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500	3"	500	5"
500	3½"	500	5½"
500	4"	500	6"

Kit No. 4	$59.95		
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1000	3"	1000	5"
1000	3½"	1000	5"
1000	4"	1000	6"

ORDERING INFORMATION:

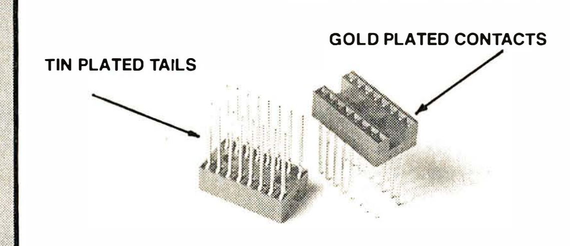
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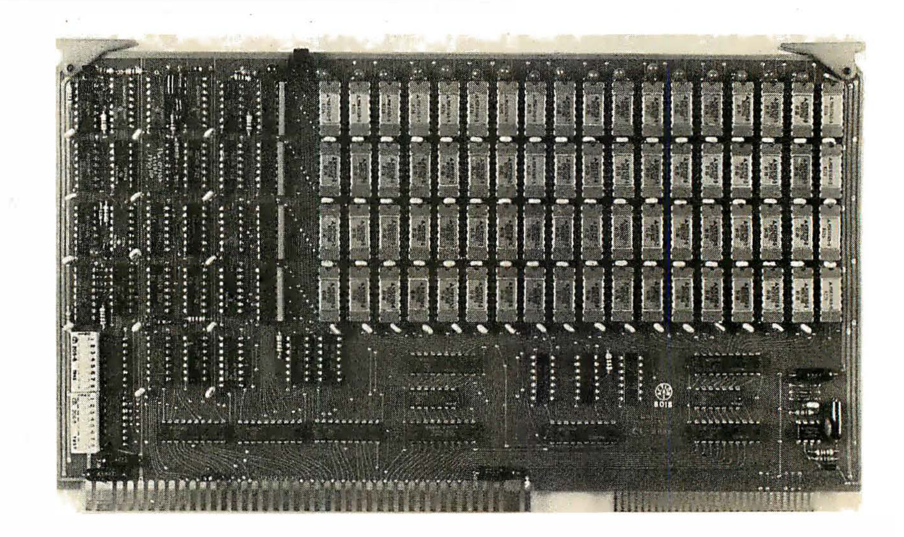
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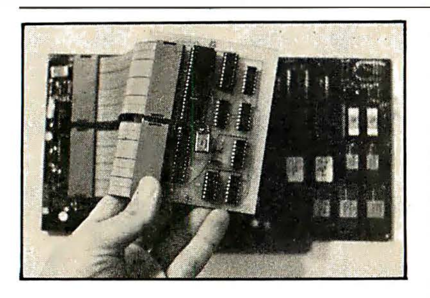
MISCELLANEOUS

Memory Board for the SBC 86/12A



The CI-8086 memory board is designed for Intel's Intellec SBC 86/12A microcomputer. Available with 32 K to 512 K bytes on a single board (depending on what memory components are used), the module is compatible with 8- and 16-bit Multibus-based systems. The CI-8086 generates and checks even parity with selectable interrupt on parity error. It features a 250 ns data-access time and a 375 ns cycle time. The memory is addressable in 16 K-byte increments up to a total of 16 megabytes of memory. Power consumption is under 8 W. The price is $1500 for the 128 K-byte board and $4700 for the 512 K-byte module. The CI-8086 is available from Chrislin Industries Inc, 31352 Via Colinas, #102, Westlake Village CA 91361, (213) 991-2254.

Circle 561 on inquiry card.



Replace an 8080 with an 8085

A 50 to 250% throughput increase can be achieved with the Series II Microprocessor Enhancement Modules. These modules perform 8080A in-circuit emulation using a code-compatible 8085A-2 microprocessor. Installation requires less than five minutes, involving only the replacement of the system 8080A processor and status latch with connectors. The modules are offered for most 8080A products at $350 in OEM (original equipment manufacturer) quantities. An Evaluation Design Pack is available for $500. Contact Paragon Systems Inc, POB 2050, Corvallis OR 97330, (503) 758-1029.

Circle 562 on inquiry card.

12-Bit CMOS Converters

The DAC1218 and the DAC1219 are 12-bit CMOS (complementary metal-oxide semiconductor), 4-quadrant, multiplying, D/A (digital-to-analog) converters. The devices offer 12-bit monotonicity, maximum differential linearity error of ±0.5 LSB (least significant bit), and feature a design technique resulting in TTL (transistor-transistor logic) compatibility. Power-supply voltages can range from +5 to +15 V; typical power consumption is 20 mW. The DAC1218 has a maximum linearity error specification of 0.012%, and the DAC1219 is rated at 0.024%.

In OEM quantities of 100, the DAC1218 sells for $10.75 each, and the DAC1219 is priced at $9.75 each. For additional information, contact National Semiconductor Corporation, 2900 Semiconductor Dr, Santa Clara CA 95051, (408) 737-5000.

Circle 563 on inquiry card.

Expand Atari's Memory

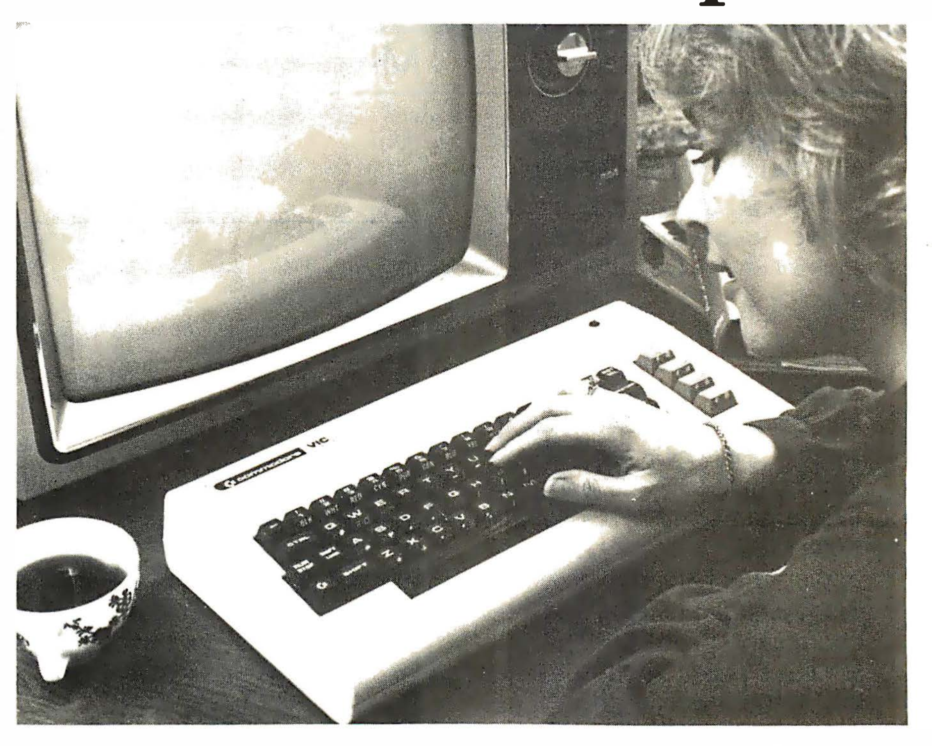
The RAMCRAM memory modules can expand the Atari 400's memory to 32 K bytes and the Atari 800's to 48 K. RAMCRAM plugs into the Atari internal memory-module slot, replacing the Atari's module. Each RAMCRAM module contains 32 K bytes of programmable memory. The suggested retail price is $320.

An 8-slot bus-expansion board for the Atari and Apple microcomputers, with power supply, controller, and software, is available for further memory expansion. This memory-board bus can hold up to eight RAMCRAMs, offering 256 K bytes of programmable memory. Its suggested retail price is $850.

For further details on both of these devices, contact Axlon Inc, 170 N Wolf Rd, Sunnyvale CA 94086, (408) 730-0216.

Circle 564 on inquiry card.

New Commodore VIC 20 Computer Now Available



Introducing the first full-featured, expandable color computer priced under $300!

Now, a new computer — the VIC 20 — offers a full range of special features and expansion capabilities which rival the features of existing microcomputers selling for 4 or 5 times as much!

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- **Language:** PETBASIC
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The new VIC computer is designed to be the most *user friendly* computer on the market...friendly in price, friendly in size, friendly to use and expand.

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The VIC 20 is designed so a first time user can begin using it immediately with plug-in program cartridges, and build his system gradually as his needs (or budget) allow.

VIC system peripherals will include a tape cassette unit, single floppy disk drive, printer — and a broad range of add-on accessories which tailor the system to a variety of applications.

FREE with purchase the VIC 20 Personal Computer Manual. This User Manual is very unique as it is the most comprehensive manual ever written for a personal computer. The key ingredient is that no previous knowledge of programming or even typewriting is required. The manual is designed for the first-time owner along with extensive appendices for both the more experienced computerists and the beginners.



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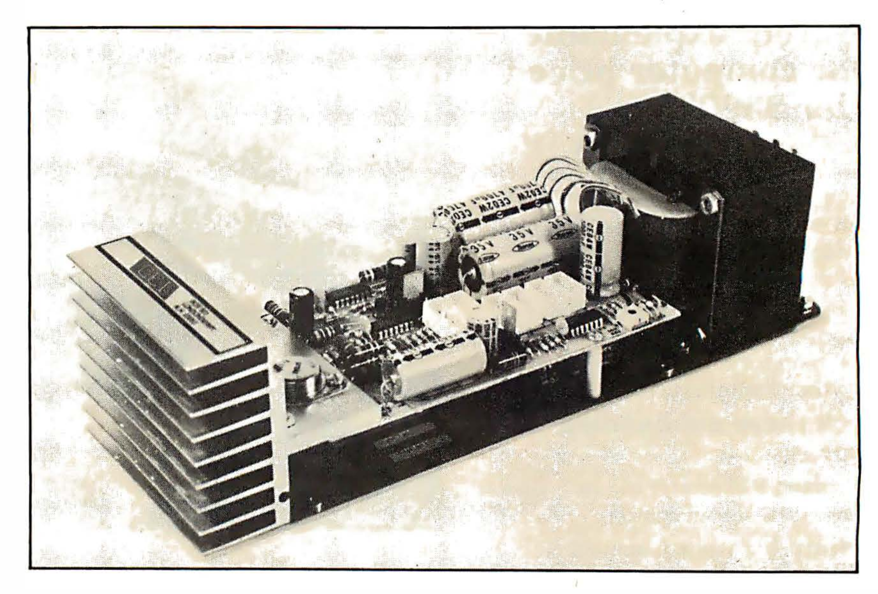
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Eight Amp Power Supply for OEMs

The CEI Model FD503 is an 8 A power supply that provides outputs of +5 VDC at 8 A, +12 VDC at 2.5 A, −5 VDC at 1 A, −12 VDC at 0.5 A, and +24 VDC at 1.5 A continuous, 4 A surge. Floppy-disk drives can plug into the output connectors of the supply. The FD503 regulates positive outputs to 0.1% and negative outputs to 1%. Options include 100, 115, or 230 VAC power use; AC step-down for 115 V Shugart motors; and interconnecting cables. The CEI FD503 is priced at $139 each in lots of 100. Contact CEI Corporation, POB 501, Grenier Industrial Park, Londonderry NH 03053, (603) 623-8888.

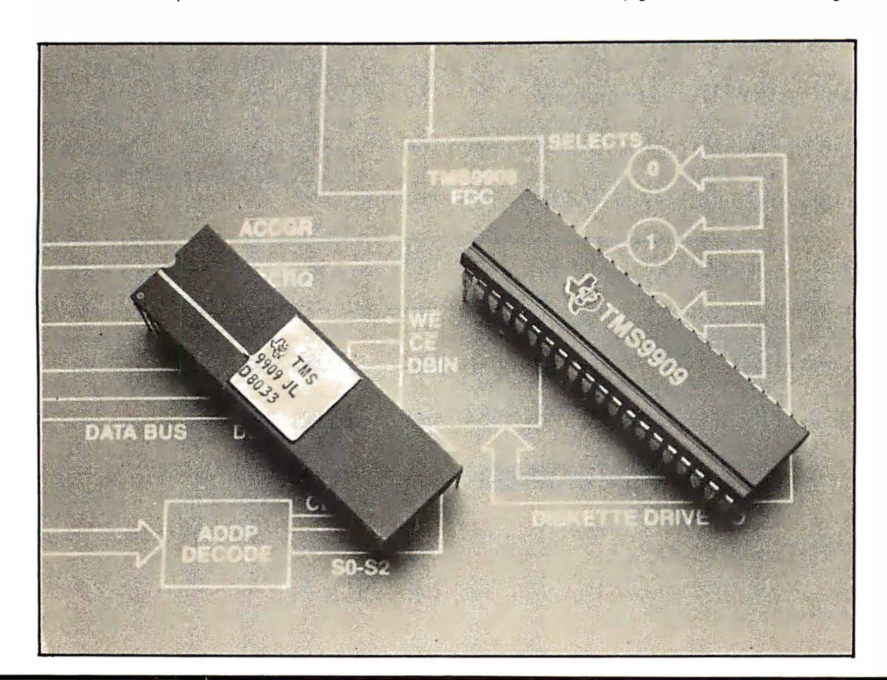


Circle 565 on inquiry card.

Universal Floppy-Disk-Controller Circuit

The TMS9909 floppy-disk-controller integrated circuit can control any floppy-disk drive while interfacing with any 8- or 16-bit microprocessor. It can read from and write onto partial sectors, read from or write onto single or multiple sectors of hard- and soft-sectored disks, as well as simultaneously control 5- and 8-inch drives. The TMS9909 provides CRC (cyclic redundancy check); data transfer rates of 125, 250, and 500 k bytes per second with one crystal; hard and soft formatting for 5- and 8-inch disks; and side selection for double-sided disks. Users can program the device for all major track parameters and various track-stepping, settling, and head-loading times. The TMS9909 supports single- and double-density formats on up to four drives. The TMS9909 has a memory-mapped microprocessor interface that supports an external DMA (direct memory access) interface. This allows designers to build only one interface for all floppy-disk formats.

For further details, contact Texas Instruments, Inquiry Answering Service, POB 25012, M/S 308, Dallas TX 75265, attn: TMS9909.



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16K Ram Card	195
Microworks DS-65 Digisector	339
SVA 8 inch Disk Controller	335
Sup-R-Mod	30
CCS Synchronous Serial Interface	159
CCS Asynchronous Serial Interface	159
Corvus 10 Meg. Hard Disk	4395
Corvus Constellation	595

MISCELLANEOUS/SUPPLIES

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Verbatium Datalife Diskette (Box of 10)	30
Dysan Diskettes (Box of 5)	22
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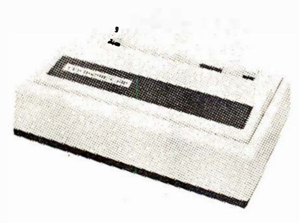
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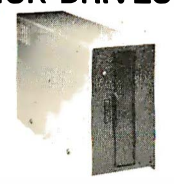
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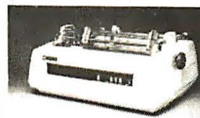
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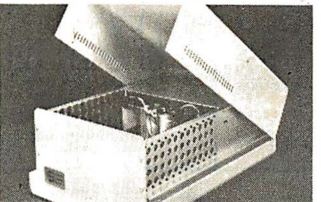
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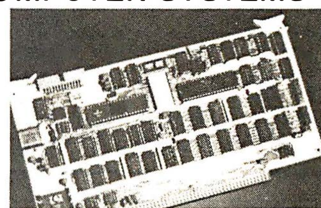
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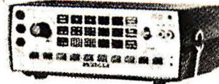


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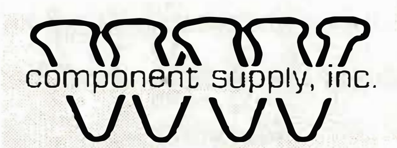
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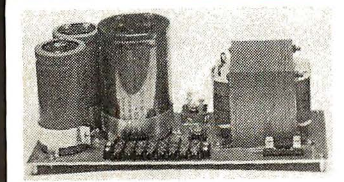
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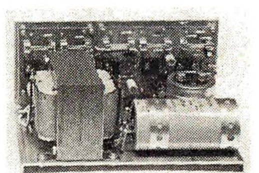
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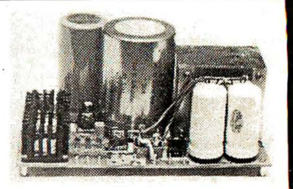
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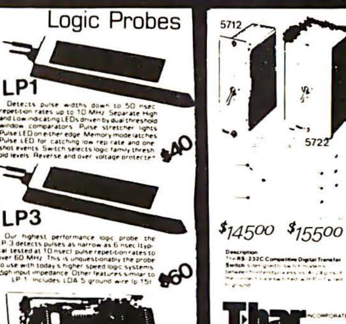
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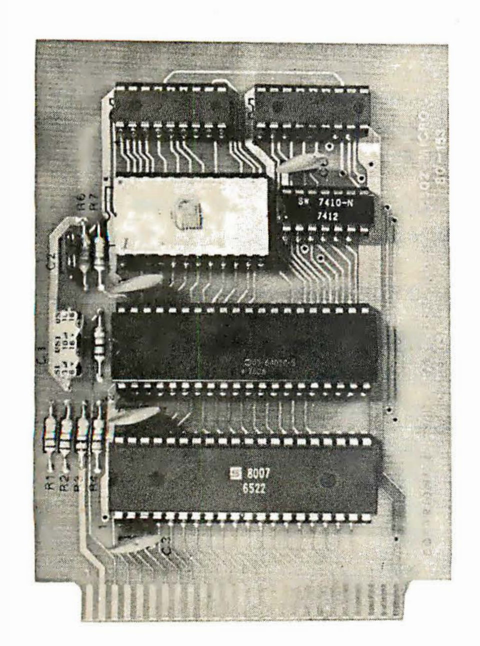


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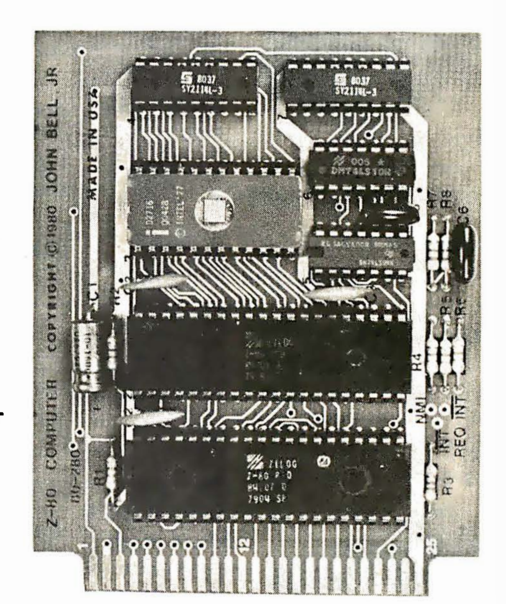
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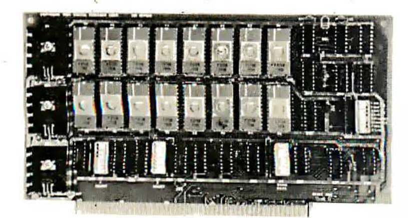
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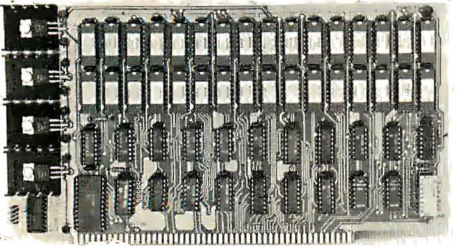
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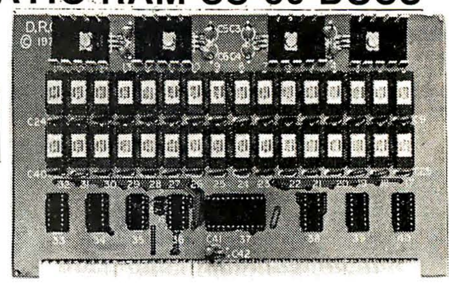
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7485N	.88
7489N	1.70
7490N	.43
7492N	.43
7493N	.43
7495N	.69
74100N	1.35
74107N	.35
74121N	.34
74123N	.59
74125N	.45
74145N	.77
74150N	1.20
74151N	.69
74154N	1.25
74157N	.69
74161N	.87
74162N	.85
74163N	.87
74174N	.96
74175N	.85
74190N	1.15
74192N	.87
74193N	.85
74221N	1.25
74298N	1.65
74365N	.75
74366N	.75
74367N	.75

74LS00 TTL	
74LS00N	.29
74LS02N	.29
74LS04N	.35
74LS05N	.25
74LS08N	.35
74LS10N	.35
74LS13N	.55
74LS14N	1.00
74LS20N	.35
74LS22N	.35
74LS28N	.35
74LS30N	.35
74LS33N	.60
74LS38N	.50
74LS74N	.45
74LS75N	.65
74LS90N	.60
74LS93N	.75
74LS95N	1.00
74LS107N	.45
74LS112N	.45
74LS113N	.45
74LS132N	.89
74LS136N	.50
74LS151N	.75
74LS155N	.79
74LS157N	1.10
74LS162N	1.10
74LS163N	1.10
74LS174N	1.15
74LS190N	1.25
74LS221N	1.25
74LS258N	1.00
74LS367N	.89

LINEAR	
CA3045	.90
CA3046	1.10
CA3081	1.80
CA3082	1.90
CA3089	3.40
LM301AN/AH	.35
LM305H	.87
LM307N	.35
LM308N	1.00
LM309K	1.25
LM311H/N	.90
LM317T	1.65
LM317K	3.75
LM318	1.50
LM320K-5	1.35
LM320K-12	1.35
LM320K-15	1.35
LM320T-5	.95
LM320T-8	.95
LM320T-12	.95
LM320T-15	.95
LM323K-5	5.95
LM324N	1.00
LM339N	1.00
LM340K-5	1.35
LM340K-8	1.35
LM340K-12	1.35
LM340K-15	1.35
LM340K-24	1.35
LM340T-5	.85
LM340T-8	.85
LM340T-12	.85
LM340T-15	.85
LM340T-18	.85
LM340T-24	.85
LM350	5.50
LM377	2.95
LM379	5.00
LM380N	1.00
LM381	1.60
LM382	1.60
LM709H	.59
LM723H/N	.50
LM733N	.85
LM741CH	.35
LM741N	.38
LM747H/N	.75
LM748N	.50
LM1303N	1.75
LM1304	1.10
LM1305	1.27
LM1307	2.00
LM1310	1.95
LM1458	.55
LM1812	7.50
LM1889	3.00
LM2111	1.75
LM2902	2.25
LM3900N	.60
LM3905	1.75
LM3909N	.95
MC1458V	.55
NE550N	1.35
NE555V	.39
NE556A	.85
NE565A	1.00
NE566V	1.50
NE567V	1.00
NE570B	4.75
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78L08	.60
78M05	.85
75108	1.75
75491CN	.50
75492CN	.55
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80388	4.50
8700CJ	13.95
8701CN	22.00
8750CJ	13.95
LD130	9.95
9400CJV/F	7.40
ICL7103	9.50
ICL7107	14.25

CMOS	
CD4000	.25
CD4001	.35
CD4002	.35
CD4006	1.10
CD4007	.35
CD4008	1.20
CD4009	.45
CD4010	.45
CD4011	.35
CD4012	.28
CD4013	.47
CD4014	1.25
CD4015	1.00
CD4016	.55
CD4017	1.05
CD4018	.94
CD4019	.45
CD4020	1.02
CD4021	1.35
CD4022	1.10
CD4023	.28
CD4024	.75
CD4025	.28
CD4026	2.50
CD4027	.66
CD4028	.85
CD4029	1.35
CD4030	.45
CD4035	1.00
CD4040	1.35
CD4042	.85
CD4043	.85
CD4044	.85
CD4046	1.67
CD4049	.45
CD4050	.60
CD4051	1.13
CD4060	1.42
CD4066	.71
CD4068	.40
CD4069	.40
CD4070	.50
CD4071	.45
CD4072	.45
CD4073	.45
CD4075	.45
CD4076	1.45
CD4078	.40
CD4081	.35
CD4082	.35
CD4116	.47
CD4490	5.50
CD4507	1.00
CD4508	2.85
CD4510	1.00
CD4511	.94
CD4515	2.52
CD4516	1.10
CD4518	1.50
CD4520	1.02
CD4527	1.51
CD4528	1.60
CD4553	3.50
CD4566	2.45
CD4583	2.35
CD4585	1.10
CD40192	3.00
74C00	.35
74C04	.40
74C10	.35
74C14	.89
74C20	.35
74C30	.35
74C48	1.95
74C74	.85
74C76	1.25
74C90	1.25
74C93	1.25
74C154	3.50
74C160	2.75
74C175	1.35
74C192	1.65
74C221	1.90
74C905	6.00
74C906	.75
74C914	1.95
74C922	5.00
74C923	5.50
74C925	7.50
74C926	6.95
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8095	.65
8096	.65
8097	.65
8098	.65
8T09	1.25
8T10	4.50
8T13	3.00
8T20	5.50
8T23	3.10
8T24	3.50
8T25	3.20
8T26	1.69
8T28	2.75
8T97	1.69
8T98	1.69

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2102-1	.95
2102AL-4	1.45
2102AN-2L	1.65
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2107B-4	3.75
2111-1	3.75
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91L02A	1.50
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MCM66751A	9.95
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410D	10.00
416	16.00

CLOCKS	
MM5311	5.50
MM5312	3.90
MM5314	3.90
MM5369	2.10
MM5841	14.45
MM5865	7.95
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CT7015	8.95
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MM5375AG/N	4.90
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7207	7.50
7208	15.95
7209	4.95
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8228	4.95
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CDP1802D	3500
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AY5-1014	7.50
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N82S137	8.75
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14	14	24	.35
16	16	28	.42
18	27	36	.58
20	29	40	.57

2 level 14pin ww .20

WIRE WRAP LEVEL 3

PIN		PIN	
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16	.49	28	1.00
18	.67	40	1.59

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4 MHz	4.25
5 MHz	4.25
10 MHz	4.25
18 MHz	3.90
20 MHz	3.90
32 MHz	3.90
32768Hz	4.00
1.8432 MHz	4.50
3.5795 MHz	1.20
2.0100 MHz	1.95
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3.2768 MHz	4.50
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5.7143 MHz	4.50
6.5536 MHz	4.50
14.31818 MHz	4.25
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AY5-3600	17.95
AY5-9100	10.50
AY5-9200	16.50
74C922	5.50
74C923	5.50
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DB25S	5.20
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DE9S	1.95
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100 per type .015
1000 per type .012
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53 key ASCII keyboard kit	6000
Fully assembled	7000
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Red TO18	.15
Green, Yellow TO18	.20
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Green, Orange, Yellow Jumbo	.25
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3 pos. slide	.25
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12.6V CT 600 ma	3.75
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10V 1.2 amp wall plug	4.85
12V 6 amp	12.95
12V 500 ma wall plug	4.75
12V 1 amp wall plug	6.50
10/15VAC 8/16VA wall plug	9.75

DISPLAY LEDS			
MAN1	CA	.270	2.90
MAN3	CC	.125	.39
MAN72/74	CA/CA	.300	1.00
DL704	CC	.300	1.25
DL707/DL707R	CA	.300	1.00
DL727/728	CA/CC	.500	1.90
DL747/750	CA/CC	.600	1.95
FND359	CC	.357	.70
FND500/507	CC/CA	.500	1.35
FND503/510	CC/CA	.500	.90
FND800/807	CC/CA	.800	2.20
3 digit Bubble			.60
10 digit display			1.25
7520 Clairex photocells			.39
TIL311 Hex			9.50
MAN3640	CC	.30	1.10
MAN4610	CA	.40	1.20
MAN4640	CC	.40	1.20
MAN4710	CA	.40	.95
MAN4740	CC	.40	1.20
MAN6640	CC	.56	2.95
MAN6710	CA	.60	1.35
MAN6740	CC	.60	1.35

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MA1012A	8.95
102P3 transformer	2.25
MA1012A Transformer	2.25

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4-position	$.95
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RCA Cosmac 1802 Super Elf Computer $106.95

Compare features before you decide to buy any other computer. There is no other computer on the market today that has all the desirable benefits of the **Super Elf** for so little money. The Super Elf is a small single board computer that does many **big** things. It is an excellent computer for training and for learning programming with its machine language and yet it is easily **expanded** with **additional memory, Full Basic, ASCII Keyboards, video character generation, etc.**

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The **Super Elf** includes a **ROM** monitor for program loading, editing and execution with **SINGLE STEP for program debugging** which is not included in others at the same price. With **SINGLE STEP** you can see the microprocessor chip operating with the **unique Quest** address and data bus displays **before, during** and **after** executing instructions. Also, CPU mode and instruction cycle are decoded and displayed on 8 LED indicators.

An RCA 1861 **video graphics** chip allows you to connect to your own TV with an inexpensive video modulator to do graphics and games. There is a **speaker system** included for writing your own music or using many music programs already written. The speaker amplifier may also be used to drive relays for control purposes.

A 24 key **HEX keyboard** includes 16 HEX keys plus **load, reset, run, wait, input, memory protect, monitor select** and **single step**. Large, on board displays provide output and optional **high** and **low address**. There is a 44 pin standard connector slot for PC cards and a 50 pin connector slot for the Quest Super Expansion Board. Power supply and sockets for **all** IC's are included in the price plus a detailed 127 pg. instruction manual which now includes over 40 pgs. of software info. including a series of lessons to help get you started and a music program and graphics target game. Many schools and universities are using the Super Elf as a course of study. OEM's use it for training and R&D.

Remember, other computers only offer Super Elf features at additional cost or not at **all. Compare before you buy. Super Elf Kit $106.95, High address option $8.95, Low address option $9.95. Custom Cabinet** with drilled and labelled plexiglass front panel **$24.95.** All metal Expansion Cabinet, painted and silk screened, with room for 5 S-100 boards and power supply **$57.00. NiCad Battery Memory Saver Kit $6.95.** All kits and options also completely assembled and tested.

Questdata, a software publication for 1802 computer users is available by subscription for $12.00 per 12 issues. Single issues $1.50. Issues 1-12 bound $16.50.

Tiny Basic Cassette **$10.00,** on ROM **$38.00,** original Elf kit board **$14.95. 1802 software;** Moews Video Graphics **$3.50.** Games and Music **$3.00,** Chip 8 Interpreter **$5.50.**

Super Expansion Board with Cassette Interface $89.95

This is truly an astounding value! This board has been designed to allow **you** to decide how you want it optioned. **The Super Expansion Board comes with 4K of low power RAM** fully addressable anywhere in 64K with built-in memory protect and a **cassette interface.** Provisions have been made for all other options on the same board and it fits neatly into the hardwood cabinet alongside the **Super Elf.** The board includes slots for up to 6K of **EPROM** (2708, 2758, 2716 or TI 2716) and is **fully socketed.** EPROM can be used for the monitor and Tiny Basic or other purposes. **A IK Super ROM Monitor $19.95** is available as an on board option in 2708 EPROM which has been preprogrammed with a program loader/editor and error checking multi file cassette read/write software, (relocatable cassette file) another exclusive from Quest. It includes register save and readout, block move capability and video graphics driver with blinking cursor. Break points can be used with the register save feature to isolate program bugs quickly, then follow with single step. If you have the **Super Expansion Board** and **Super Monitor** the monitor is up and running at the push of a button.

Other on board options include **Parallel Input and Output Ports** with **full handshake.** They allow easy connection of an ASCII keyboard to the input port. **RS 232 and 20 ma Current Loop** for teletype or other device are on board and if you need more memory there are two **S-100** slots for static RAM or video boards. Also a 1K Super Monitor version 2 with video driver for full capability display with Tiny Basic and a video interface board. **Parallel I/O Ports $9.85, RS 232 $4.50, TTY 20 ma I/F $1.95, S-100 $4.50. A 50 pin connector set** with ribbon cable is available at $15.25 for easy connection between the **Super Elf** and the **Super Expansion Board.**

Power Supply Kit for the complete system (see Multi-volt Power Supply).

Quest Super Basic V5.0

A new enhanced version of **Super Basic** now available. Quest was the first company worldwide to ship a full size Basic for 1802 Systems. A complete function **Super Basic** by **Ron Cenker** including floating point capability with scientific notation (number range $\pm .17E^{38}$), 32 bit integer ± 2 billion; multi dim arrays, string arrays; string manipulation; cassette I/O; save and load, basic, data and machine language programs; and over 75 statements, functions and operations.

New improved faster version including **re-number** and essentially **unlimited variables.** Also, an exclusive user expandable command library.

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Super Basic on Cassette $55.00.

Ohio Scientific Computers

CIP Series 2 **$455.00.** Like an Apple at less than half the price! CIPMF Series 2 **$1199.00.** Minifloppy version with additional RAM/ROM. Complete software and peripherals available. Send for free brochure.

Elf II Adapter Kit $24.95

Plugs into Elf II providing Super Elf 44 and 50 pin plus S-100 bus expansion. (With Super Expansion). High and low address displays, state and mode LED's optional **$18.00.**

Gremlin Color Video Kit $69.95

32 x 16 alpha/numerics and graphics; up to 8 colors with 6847 chip; 1K RAM at E000. Plugs into Super Elf 44 pin bus. No high res. graphics. On board RF Modulator Kit **$4.95**

Super Color S-100 Video Kit $129.95

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1802 16K Dynamic RAM Kit $149.00

Expandable to 32K. Hidden refresh w/clocks up to 4 MHz w/no wait states. Addl. 16K RAM **$63.00**

Tiny Basic Extended on Cassette	**$15.00**
(added commands include Stringy, Array, Cassette I/O etc.) S-100 4-Slot Expansion	**$ 9.95**
Super Monitor VI.I Source Listing	**$15.00**

Dealers: Send for excellent pricing/margin program.

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(Requires minimum of 4K for E/A plus user source)	
1802 Tiny Basic Source listing	**$19.00**
Super Monitor V2.0/2.1 Source Listing	**$20.00**

PROM Eraser

assembled. 25 PROM capacity **$37.50** (with timer **$69.50**). 6 PROM capacity OSHA/UL version **$69.50** (with timer **$94.50**).

Z80 Microcomputer

16 bit I/O, 2 MHz clock, 2K RAM, ROM Breadboard space. Excellent for control. Bare Board **$28.50.** Full Kit **$99.00.** Monitor **$20.00.** Power Supply Kit **$35.00. Tiny Basic $30.00**

S-100 Computer Boards

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24K Static Godbout Econo XX-24 Kit	414.00
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Opens shorted cells that won't hold a charge and then charges them up, all in one kit w/full parts and instructions. **$7.95**

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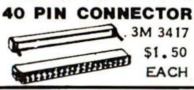
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YOUR BOYFRIEND MADE YOU COME HERE - THAT'S INTERESTING
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WHAT WOULD IT MEAN TO YOU IF YOU GOT SOME HELP?
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3.067-B	6.75840-B	11.2890-B	28.7538-B	39.9628-B	43.4378-B	51.0556-B
3.200-B	6.9003-B	11.4776-B	29.8758-B	40.4448-B	43.4448-B	51.3128-B
3.2768-A	7.0063-B	11.6566-B	29.9378-B	40.5928-B	43.5558-B	51.7778-B
3.500-B	7.0336-B	11.6816-B	30.0648-B	40.8128-B	43.6298-B	51.8506-B
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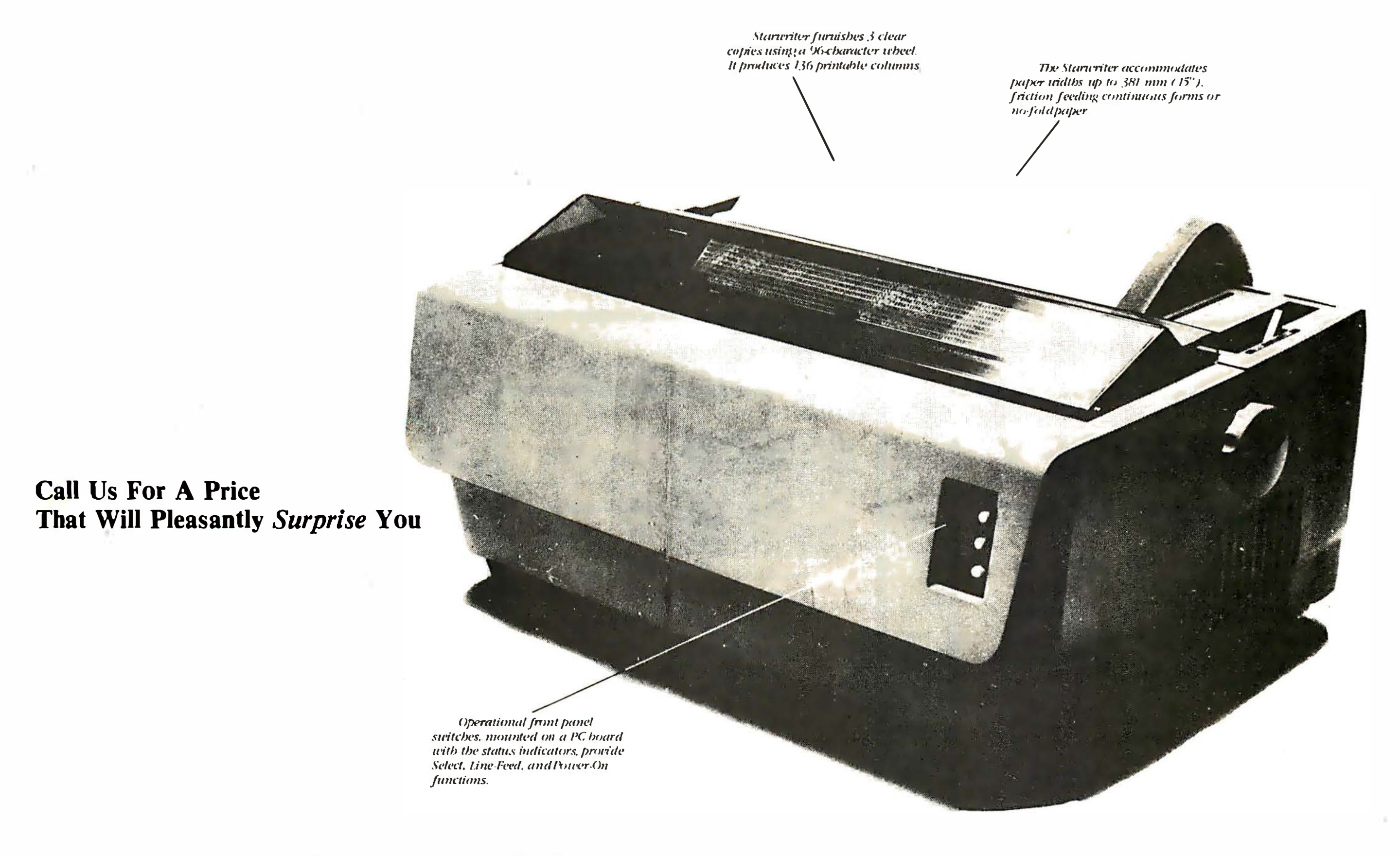
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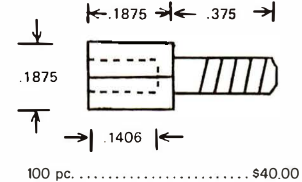
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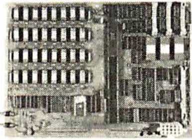
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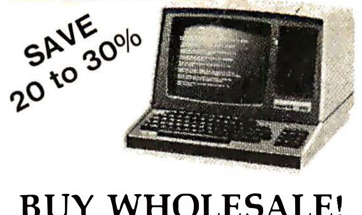
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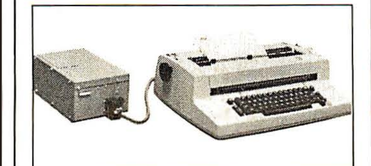
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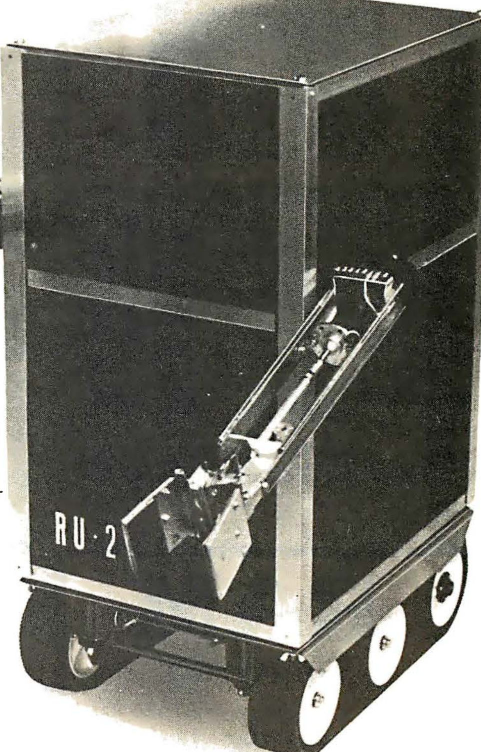
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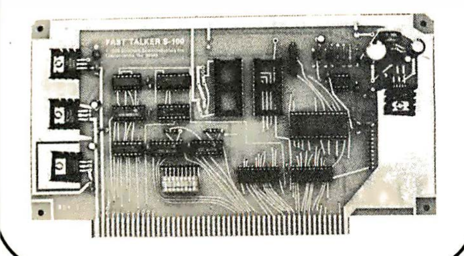
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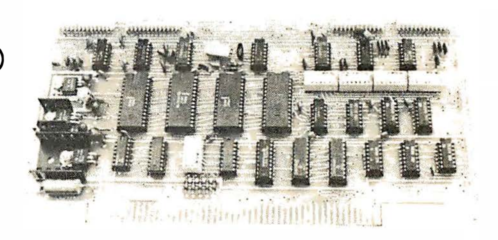
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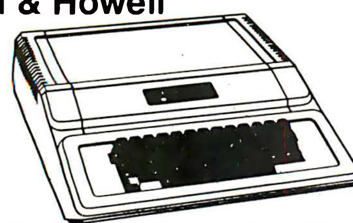
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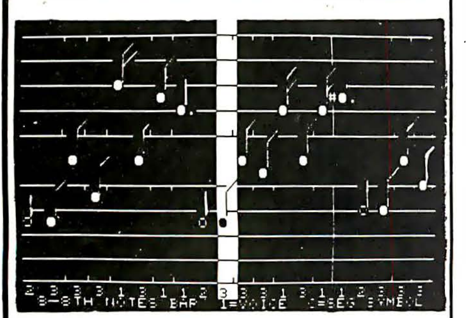
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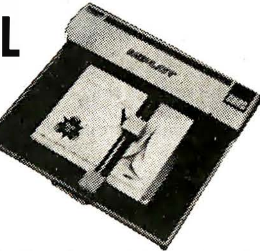
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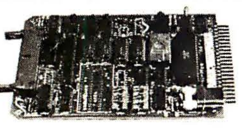
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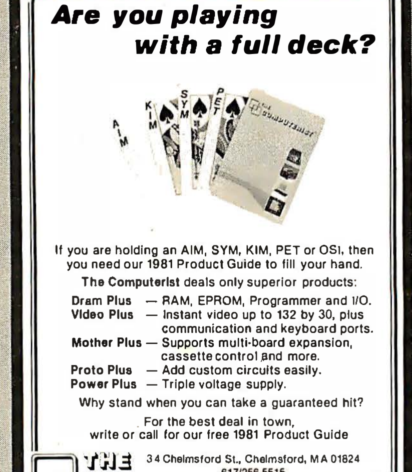
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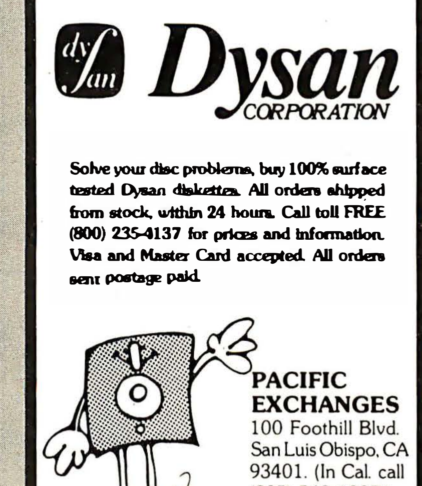


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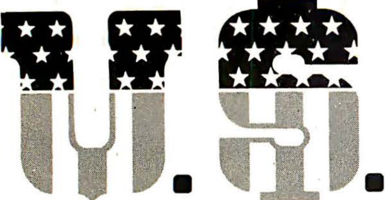
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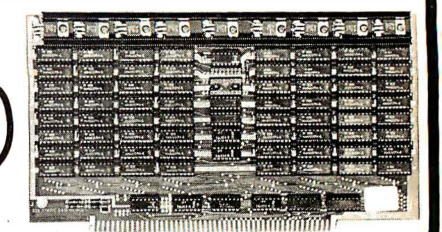
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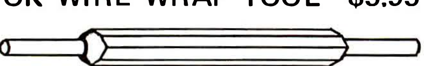
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74LS03	.33	74LS113	.59	74LS242	1.95
74LS04	.59	74LS114	.49	74LS243	1.95
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74LS06	.39	74LS123	1.19	74LS245	8.95
74LS07	.39	74LS124	1.49	74LS247	1.19
74LS08	.59	74LS125	.89	74LS248	1.19
74LS09	.39	74LS126	.89	74LS249	1.69
74LS10	.29	74LS132	.79	74LS251	1.79
74LS11	.39	74LS133	1.19	74LS253	.95
74LS12	.39	74LS136	.69	74LS257	1.95
74LS13	.69	74LS138	.99	74LS258	1.95
74LS14	1.25	74LS139	.99	74LS259	2.95
74LS15	.49	74LS145	1.25	74LS260	.75
74LS20	1.95	74LS148	1.49	74LS266	1.15
74LS21	3.7	74LS151	.79	74LS273	1.75
74LS22	.29	74LS154	2.49	74LS275	4.39
74LS26	.39	74LS155	1.49	74LS279	.79
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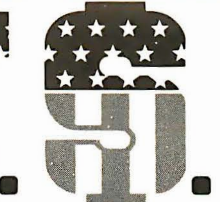
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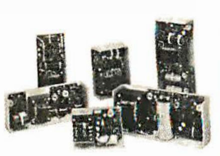
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POWER SUPPLIES



If you can beat these prices we will be truly amazed. OEM's at 500 lot pay more than this. Call or write for full spec. sheets.

DISK POWER SUPPLIES				
PRIAM–SHUGART–CENTURY–MICROPOLIS				
+5V @ 9A	–5V @ .8A	+24V @ 7A	US-384	89.00
SHUGART – SIEMANS – MPI 5¼"				
+5V @ .5A	+12V @ .9A		US-340	33.50
+5V @ 2A	+12V @ 4A		US-323	56.25
SHUGART – SIEMANS – CDC 8"				
+5V @ 1A	–5V @ .5A	+24V @ 1.5A	US-205	52.50
+5V @ 2A	–5V @ .5A	+24V @ 3A	US-206	69.00
+5V @ 3A	–5V @ .6A	+24V @ 5A	US-162	89.00
+5V @ 1.7A	–5V @ 1.5A	+24V @ 2A	US-272	69.00
+5V @ 2A	+12V @ .4A	–12V @ .4A	US-HTAA	37.50

TELEVIDEO 950

Televideo 950 –$950.00
Televideo 912C– 665.00
Televideo 920C– 720.00
ADDS R-25 – 710.00



Also have 920C, SOROC, HAZELTINE, etc. What we don't have is room on this page. Call Toll Free 800 number for prices.

C-ITOH PRINTER

$499.00



Look closely at the photo and see other adds in this rag at $995.00. Perfect units, warranteed. Only 500 pcs. Same story, manufacturerer had too many.

S-100 CARD EXTENDER

$12.50

(Gold Contacts)



As long as there is a price war, we will fight your battle. Compare at your local Dept. store and buy U$ MICRO.

MEMOREX – VERBATUM – WABASH BASF FLOPPIES

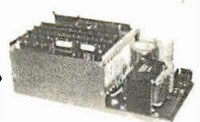
BOX OF 10 ONLY:

5¼"	SOFT	$2.65 ea.
5¼"	HARD 10	2.65 ea.
5¼"	HARD 16	2.65 ea.
8"	SOFT 1D	3.25 ea.
8"	SOFT 2D	3.85 ea.
8"	SOFT 2DDS	5.00 ea.

SPECIAL OF THE QUARTER

S1-MOD (KIT)

$189.00 MADE IN USA



Complete S-100 12 Slot Computer. Ample system power with regulated power for drives. Excellent for Subsystem or Hobby use. 4 hours to build. (6 conn. incl., less fans)

DUAL DRIVE SUBSYSTEM

$995.00

$195.00 w/no Drives

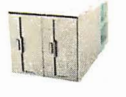


If this looks like a Lobo Drive System, don't be fooled. Just because it looks like one, works like one, smells like one, and tastes like one (?) doesn't mean it has to cost like one!

2 SHUGART 801R POWER SUPPLY

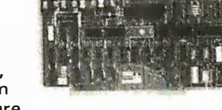
TWIN VERTICAL DRIVE$

5" $550.00 – 8" $980.00



Attractive, convenient and compact Two Drive Mass Storage includes Power Supply, Drives, Cabinets and Cables. Double Sided, Double Track available too! $145.00 Kit (Less Cable)

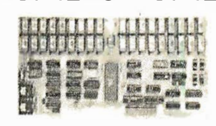
Z-80 CPU (KIT)



The first time this world popular CPU offered in Kit. 2 serial, 3 parallel, CTC, EProm Z-80 at 4 mhz. Software buad rate, etc. (less Prom & cable) $212.00

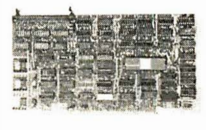
EXPANDABLE RAM

★SPECIAL★SPECIAL★SPECIAL★



This is the best all around 64K board you can buy. If after you see it, you don't agree return for full refund. Bank Select by extended address lines or I.O. 40H. ★$389.00 A&T★

U$ – D$K $255.00



Double Density 8" and 5" Disk Controller disigned for S-100 IEEE standards. Uses Western Digital 1795, 1691 2143 Chip Set.

FANS $14.95



These are brand new, in the box fans. Not noisey bearing pullouts. Never again at these low prices!

3-1/8" 4-5/8"

SPECIALS OF THE MONTH

4116s $3.25

Expansion 16K Dynamic RAMs for Apple, TRS-80 S-100 systems. T.I., Mostek Intel, Call for manufacturer. 200 NS

INTEL

8251 $4.95
8255 $6.50

VERY POPULAR I.O. CHIPS BY LEADING MANUFACTURER

2114s $2.95

One of the world's two most popular STATIC RAMs. Factory prime tested units. Sold in lots of 8 only. FUJITSU, HITACHI, etc. 200 NS

TMS-4044 MM-5257 INTEL 2147 $4.25

250 NS

CMOS Version $4.50!

The other of the world's most popular STATIC RAMs. This one is 4K by 1 organization. Don't buy Gold, buy these, the price won't last!

2716s $7.50 (450 NS)
2708s $6.95 (450 NS)

Remember when 2716s were $50.00 and hard to get? These units are so beautiful it's hard to part with them. But we will, for a small price. Guaranteed!

SHUGART DRIVE



8" 801R $395.00

8" 851R $585.00

Manufacturer had too many, buys at 1000 piece rate, sales dropped, so we got'em. Fantastic buy, get them while they last! Full warranty.

SIEMANS DRIVE

8" 100-8 $375.00

Very Special Price on these BRAND NEW current production units Add $10.00 for Extended 1 Year Warrantee!

7400

SN7400N	.19	SN74123N	.59
SN7401N	.22	SN74125N	.39
SN7402N	.22	SN74126N	44
SN7403N	.22	SN74128N	.59
SN7404N	.22	SN74132N	.69
SN7405N	.23	SN74136N	.95
SN7406N	.23	SN74139N	95
SN7407N	.23	SN74141N	.69
SN7408N	.26	SN74142N	2.95
SN7409N	.23	SN74143N	2.95
SN7410N	.22	SN74144N	2.95
SN7411N	.29	SN74145N	.62
SN7412N	.29	SN74147N	1.95
SN7413N	.39	SN74148N	1.20
SN7414N	.59	SN74150N	.99
SN7416N	.29	SN74151N	.67
SN7417N	.29	SN74152N	.67
SN7420N	.22	SN74153N	.67
SN7421N	.35	SN74154N	1.19
SN7422N	.29	SN74155N	.82
SN7423N	.29	SN74156N	.89
SN7425N	.29	SN74157N	.69
SN7426N	.29	SN74158N	1.65
SN7427N	.29	SN74160N	.95
SN7429N	.45	SN74161N	.95
SN7430N	.23	SN74162N	.89
SN7432N	.29	SN74163N	.87
SN7437N	.29	SN74164N	.97
SN7438N	.29	SN74165N	.97
SN7439N	.29	SN74166N	1.20
SN7440N	.24	SN74167N	1.95
SN7441N	.79	SN74170N	1.69
SN7442N	.57	SN74172N	5.95
SN7443N	.79	SN74173N	.79
SN7444N	.79	SN74174N	.89
SN7445N	.79	SN74175N	.89
SN7446N	79	SN74176N	.85
SN7447N	.59	SN74177N	.85
SN7448N	.79	SN74179N	1.80
SN7450N	.23	SN74180N	.75
SN7451N	.23	SN74181N	1.75
SN7453N	.23	SN74182N	.75
SN7454N	.23	SN74184N	1.95
SN7459N	.29	SN74185N	1.95
SN7460N	.23	SN74186N	9.95
SN7470N	.39	SN74188N	3.90
SN7472N	.34	SN74190N	1.15
SN7473N	.38	SN74191N	1.15
SN7474N	.36	SN74192N	.85
SN7475N	.38	SN74193N	.85
SN7476N	.36	SN74194N	.85
SN7479N	4.60	SN74195N	.85
SN7480N	.59	SN74196N	.85
SN7481N	1.10	SN74197N	.85
SN7482N	1.10	SN74198N	1.39
SN7483N	.55	SN74199N	1.39
SN7485N	.65	SN74221N	1.39
SN7486N	.39	SN74251N	.95
SN7489N	1.75	SN74273N	1.05
SN7490N	.39	SN74279N	.89
SN7491N	.65	SN74283N	2.15
SN7492N	.52	SN74284N	3.90
SN7493N	.49	SN74285N	3.90
SN7494N	.72	SN74290N	1.25
SN7495N	.65	SN74298N	.95
SN7496N	.72	SN74365N	.68
SN7497N	3.10	SN74366N	.68
SN74100N	.99	SN74367N	.79
SN74107N	.32	SN74368N	.79
SN74109N	.53	SN74390N	1.90
SN74116N	1.95	SN74393N	1.90
SN74121N	.29	SN74490N	1.90
SN74122N	.39		

CMOS

CD4000	.35	CD4093	.99
CD4001	.35	CD4094	2.95
CD4002	.35	CD4098	2.49
CD4006	1.39	CD4099	2.25
CD4007	.29	MC14408	12.95
CD4008	1.39	MC14409	12.95
CD4009	.49	MC14410	12.95
CD4010	.49	MC14412	12.95
CD4011	.35	MC14415	8.95
CD4012	.29	MC14419	4.95
CD4013	.49	CD4501	.39
CD4014	1.39	CD4502	1.65
CD4015	1.15	CD4503	.69
CD4016	.59	CD4505	8.95
CD4017	1.19	CD4506	.75
CD4018	.99	CD4507	.95
CD4019	.49	CD4508	3.95
CD4020	1.19	CD4510	1.39
CD4021	1.19	CD4511	1.39
CD4022	1.15	CD4512	1.39
CD4023	.38	CD4515	3.95
CD4024	.79	CD4516	1.69
CD4025	.38	CD4518	1.39
CD4027	.65	CD4520	1.39
CD4028	.85	CD4555	4.95
CD4029	1.29	CD4556	.99
CD4030	.45	CD4566	2.25
CD4031	3.25	74C00	.39
CD4032	2.15	74C02	.39
CD4034	3.25	74C04	.39
CD4035	.95	74C08	.49
CD4037	1.95	74C10	.49
CD4040	1.29	74C14	1.65
CD4041	1.25	74C20	.39
CD4042	.95	74C30	.39
CD4043	.85	74C32	.99
CD4044	.85	74C42	1.85
CD4046	1.75	74C48	2.39
CD4047	1.25	74C73	.85
CD4048	.99	74C74	.85
CD4049	.69	74C85	2.49
CD4050	.69	74C89	4.95
CD4051	1.10	74C90	1.85
CD4052	1.10	74C93	1.85
CD4053	1.10	74C95	1.85
CD4055	3.95	74C107	1.19
CD4056	2.95	74C151	2.49
CD4059	9.95	74C154	3.50
CD4060	1.39	74C157	2.10
CD4066	.75	74C160	2.39
CD4069	.35	74C161	2.30
CD4070	.49	74C163	2.39
CD4071	.35	74C164	2.39
CD4072	.35	74C173	2.59
CD4073	.35	74C174	2.75
CD4075	.35	74C175	2.75
CD4076	1.29	74C192	2.39
CD4077	.35	74C193	2.39
CD4078	.35	74C195	2.39
CD4081	.35	74C922	7.95
CD4082	.35	74C923	6.95
CD4085	1.95	MM80C95	1.50
CD4089	2.95	MM80C97	1.25

74LS00

74LS00N	.35	74LS164N	1.19
74LS01N	.28	74LS165N	.89
74LS02N	.28	74LS166N	2.48
74LS03N	.28	74LS168N	1.89
74LS04N	.39	74LS169N	1.89
74LS05N	.28	74LS170N	1.99
74LS08N	.39	74LS173N	.89
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74LS10N	.28	74LS175N	.99
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74LS13N	.47	74LS191N	1.15
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74LS28N	.39	74LS240N	1.95
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74LS73N	.45	74LS258N	.98
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74LS75N	.68	74LS260N	.69
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74LS78N	.65	74LS266N	.59
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74LS90N	.75	74LS283N	1.10
74LS92N	.75	74LS290N	1.29
74LS93N	.75	74LS293N	1.95
74LS95N	.88	74LS295N	1.10
74LS96N	.98	74LS298N	1.29
74LS107N	.45	74LS324N	1.75
74LS109N	.45	74LS347N	1.95
74LS112N	.49	74LS348N	1.95
74LS113N	.49	74LS352N	1.65
74LS114N	.55	74LS353N	1.65
74LS122N	.55	74LS363N	1.49
74LS123N	1.19	74LS365N	.99
74LS124N	1.35	74LS366N	.99
74LS125N	.89	74LS367N	.73
74LS126N	.89	74LS368N	.73
74LS132N	.79	74LS373N	2.75
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74LS153N	.79	74LS393N	1.95
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74LS155N	1.19	74LS399N	2.95
74LS156N	.99	74LS424N	2.95
74LS157N	.99	74LS668N	1.75
74LS158N	.75	74LS670N	2.29
74LS160N	.98	81LS95N	1.99
74LS161N	1.15	81LS96N	1.99
74LS162N	.98	81LS97N	1.99
74LS163N	.98	81LS98N	1.99

LINEAR

78H05	5.95	LM1414N	1.90
78M06	1.49	LM1458CN/N	.49
78M.G.	1.49	MC1488N	1.49
LM105H	.99	MC1489N	1.49
LM108AH	2.95	LM1496N	.89
LM300H	.79	LM1556N	1.50
LM301CN/H	.35	LM1800N	.79
LM304H	.98	LM1820N	.95
LM305H	.89	LM1850N	.95
LM306H	3.25	LM1889N	3.95
LM307CN/H	.29	LM2111N	1.75
LM308CN/H	.98	LM2900N	.99
LM309K	1.49	LM2901N	2.50
LM310CN	1.25	LM2917N	2.95
LM311D/CN/H	.98	CA3013T	2.29
LM312H	1.75	CA3018T	1.99
LM317T	2.75	CA3021T	3.49
LM318CN/H	1.49	CA3023T	2.99
LM319N/H	1.25	CA3035T	2.75
LM320K-XX*	1.49	CA3039T	1.49
LM320T-XX*	1.25	CA3046T	1.29
LM320H-XX*	1.25	LM3053N	1.49
LM323K	4.95	CA3059N	3.25
LM324N	1.25	CA3060N	3.25
LM339N	.95	CA3062N	4.95
LM340K-XX*	1.49	LM3065N	1.49
LM340T-XX*	1.25	CA3080N	1.29
LM340H-XX*	1.25	CA3081N	1.69
LM344H	1.95	CA3082N	1.69
LM348N	1.85	CA3083N	1.99
LM358CN	.98	CA3086N	1.29
LM360N	1.49	CA3089N	2.75
LM372N	1.95	CA3096N	2.49
LM376N	3.75	CA3097N	1.99
LM377N	3.75	CA3130T	2.49
LM380CN/N	1.25	CA3140T	2.49
LM381N	1.79	CA3146N	2.49
LM383T	1.95	CA3160T	1.49
LM386N	1.49	CA3190N	1.95
LM387N	1.49	CA3401N	.69
LM390N	1.95	MC3423N	1.49
NE531V/T	3.75	MC3460N	3.95
NE555V	.39	SG3524N	3.95
NE556N	.98	CA3600N	3.50
NE561T	19.95	LM3900N	.59
NE562B	7.95	LM3905N	1.49
NE565N/H	1.25	LM3909N	.98
NE566H/V	1.75	RC4131N	2.95
NE567V/H	1.50	RC4136N	1.10
NE592N	2.75	RC4151N	4.50
LM702H	2.99	RC4194	4.95
LM709N/H	.29	RC4195	4.40
LM710N/H	.98	ULN2001	1.25
LM711N/H	.39	ULN2003	1.50
LM715N	1.95	SN75450N	.59
LM723N/H	.75	SN75451N	.49
LM733N/H	.98	SN75452N	.49
LM739N	1.15	SN75453N	.49
LM741CN/H	.33	SN75454N	.49
LM741CN-14	.19	SN75491N	.89
LM747N/H	.79	SN75492N	.89
LM748N/H	.39	SN75493N	.89
LM760CN	2.95	SN75494N	.89
LM1310N	1.90		

16K UPGRADE ONLY $39.95 SPECIFY COMPUTER

ADVANCED COMPUTER PRODUCTS

NON-LINEAR SYSTEMS, INC. NLS
TOUCH TEST 20
DIGITAL MULTIMETER

The NLS Model Touch/Test 20 is a 3½ digit digital multimeter with capability of measuring 10 parameters including 20 functions and 44 ranges. Features touch selection and annunciator lamp indication of control settings which include function, range and on-off power.



$319.95

BECKMAN
Digital Multimeters
MODELS TECH 300 AND TECH 310

AS LOW AS $100

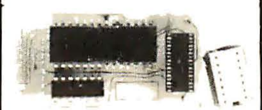


Choice of Models – The TECH 310 has all above features 7 functions 29 ranges plus 0.25% Vdc accuracy
The TECH 300 has a 0.5% Vdc accuracy and all the above features, but without Insta-Ohms™ continuity function or the 10 amp current ranges

TECH 300 Digital Multimeter	$110
TECH 310 Digital Multimeter	$140
TECH 330 Digital Multimeter	$189
VC-201 Vinyl Carrying Case	$10
DC-202 Deluxe Carrying Case	$24
HV-211 High Voltage Probe	$35
RP-221 RP Probe	$35
CI-231 AC Current Clamp	$42
DL-241 Deluxe Test Lead Kit	$10
TL-242 Spare Test Leads	$6



VISTA COMPUTER COMPANY
APPLE™ 40 CHARACTER TYPE-AHEAD BUFFER
MODEL 150

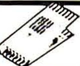


$49.95

CSC CONTINENTAL SPECIALTIES

Model LM-3 40-channel Logic Monitor	585.00
Model LM-1 Logic Monitor	60.00
Model LM-2 Logic Monitor	147.00
MAX-100 100 MHz Portable Frequency Counter	149.00
Model LP-1 Digital Logic Probe	50.00
Model LP-2 Economy Logic Probe	28.00
Model LP-3 High Speed Logic Probe	77.00
Model LPK-1 Logic Probe Kit	21.95
Model LTC-1, LTC-2 Logical Analysis Kits	220/250

Proto Clips



14-Pin Clip	PC-14	$ 4.25
16-Pin Clip	PC-16	$ 4.50
24-Pin Clip	PC-24	$ 9.50
40-Pin Clip	PC-40	$14.95

Proto Boards

PB-6	16.95	PB-104	54.00
PB-100	18.00	PB-203	97.00
PB-101	21.00	PB-203A	149.00
PB-102	25.00	PB-203A-Kit	129.00
PB-103	43.00		

SEMICONDUCTORS SPEAK ☆☆☆☆☆☆

DIGITALKER™
Speech Synthesis System

The DIGITALKER is a speech synthesis system consisting of multiple N-channel MOS integrated circuits. It contains a speech processor chip (SPC) and speech ROM and when used with external filter, amplifier, and speaker, produces a system which generates high quality speech including the natural inflection and emphasis of the original speech. Male, female, and children's voices can be synthesized

- Completely independent system, not requiring a processor controller
- Designed to be easily interfaced to most popular microprocessors
- 256 possible addressable expressions
- Male, female, and children's voices
- Natural infrection and emphasis of original speech
- Addresses 128k of ROM directly
- Communicates with static or clocked dynamic ROMs
- TTL compatible
- MICROBUS™ compatible

DIGITALKER™ DT1000. Self contained board that – with just a speaker and a power supply – can rattle off any desired combination of 144 words. $485.00

DIGITALKER™ DT1050. Chipset for building Digitalker into your own evaluation design. $95.00

National Semiconductor



DISK SYSTEM SPECIAL

Apple II Plus w/48K Supermod Video Modulator
Disk II w/Controller Integer Based ROM Card.

ACP PRICE $1995.00

Hi-Speed Serial I/O	$18900	DS65 Digi-Sector	$34900	Integer ROM Card	$18900
Centronics Printer I/O	180.00	Apple Graphics Tablet	67500	Proto Card	2195
Applesoft II Firmware	18900	DC Hayes Modem II	34995	M & R Modulator	2995
Apple Clock	26900	Disk II w/Controller & Dos 3.3	59500	Cassette	54.95
Introl X-10 System	17995	Disk II	459.00	16K Upgrade Kit	54.95
Introl X-10 Controller	269.95	Pascal Lang System	450.00	Desktop Plan	9800
All Music Synthesizer	25995	Parallel Printer Card	16500	8" Floppy Controller	35000
16 Ch Analog Input	24995	Communications Card	18900	Heuristics Speechlab	17900
2 Ch Analog Output	16495	Business Software Pkg	62500	Romplus +	16900
13-Key Keypad	11995	Corvus 10 Megabyte Drive	4625.00	Supertalker	27900
Visi-Calc	12500			Cashier	25000

apple /// $3995

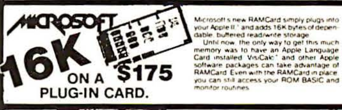
- Apple III Option A: Apple III 96K, Information Analyst Package, 12" B/W Monitor $3995.00
- Apple III Option B: Same as Option A Plus: Disk II for Apple III $4395.00
- Apple III Option C: Same as Option A Plus: Disk II for Apple III, Silentype Thermal Printer $4785.00
- To substitute 128K Apple III for 96K Apple III .... Add $450.00

NEW APPLE PRODUCTS

- "APPLE FAN" – Cures thermal problems from overcrowded machines designed specifically for Apple $4995
- "BIT 3" – New 80 x 24 Video Board for Apple. Completely compatible with Pascal $32995
- "BARWAND" Hewlett Packard HEDS-3000 Bar Code interfaced to Apple $19900
- "SEC APPLE A/D" – 8 Channel A/D Interface completely assembled and tested $9950
- "APPLE FORTRAN" $17500
- "APPLE CRYPTEXT" for data encryption and security $44900
- "B2/A2" Graphics Interface Card by Base 2 $159.95
- 8" Disk Drives for Apple, Controller, DOS, Two 8" drives cabinet and cable $145000
- "MICROMODEM" – DC Hayes $31995
- "DIGISECTOR" Converts video input to Hi-Res graphics $34995
- California Microproducts VisiCalc Keypads Numberic keypad with space, space ESC · and · keys for VisiCalc compatibility $169.00
- DOS 3.3 Upgrade Kits 23% more storage in 16-sector format $6500
- Mountain Hardware Music Board, best yet – 16 channels $55000
- Controller 1.1 Revision Kit. 20% overall processing speed increase and supports standard printers. Reduced disk handling. Additional error checking. Improved manual. Vendor file expanded $145.00
- Pascal Revision Kit. Adds executive and chaining capabilities to Pascal environment $6500
- Mountain Hardware Expansion chassis. 8 more slots for Apple. Hardware or software selectable. Includes power supply Avail Soon
- Smart Term Apple 80 x 24 Video Card $619.00
- Symtex X-10 $349.00
- Apple Silentype With Apple Intelligent Interface Card $54900
- NEW! California Computer Systems APPLE Clock Only $12495
- NEW! Z-80 Softcard for APPLE CPM 2.2 & M BASIC 5.0 $325.00
- SEC ECHO II Speech Synthesizer $249.95

NEW APPLE SOFTWARE

1. CYBERSTRIKE – Apple II version of Star Raiders from Atari on disk $3495
2. RTR Stock Market Analysis – Hi-Res, TrendLines, etc. $109.95
3. ASTEROIDS $29.95
4. "Both Barrels" – Hi-Res simulation of Western Gunfight and Skeet Shooting. Same author as Nasir $2995
5. "Apple Tax Planner Package" $89.95
6. "New-DOS Tool Kit" $6495
7. NEW! Apple Z-80 CP/M Software Call for Price



Microsoft's new RAMCard simply plugs into your Apple II™ and adds 16K bytes of dependable, buffered read/write storage.
Until now, the only way to get this much memory was to have an Apple Language Card installed. VisiCalc™ and other Apple software packages can take advantage of RAMCard. Even with the RAMCard in place you can still access your ROM BASIC and monitor routines.

EXPANSION CHASSIS

By popular demand! Eight more slots for your Apple. Attractive sturdy enclosure. Its own heavy duty power supply. Easy to use. Address cards in Expansion Chassis the same way as in your Apply. Only one additional command to specify in Apple or in Expansion Chassis.

$649.00



ATARI® 800 & 400
Personal Computer System

ATARI 800 $825.00
ATARI 400 $449.00

ATARI 800 Includes: Computer Console, BASIC Lang. Cartridge, BASIC Language Programming Manual. 800 Operator's Manual w/Notebook, 16K RAM Module, Power Supply, TV Switch Box.

Peripherals		**Education System Cassette Programs**		Spelling	3500
Disc Drive	59900	U.S. History	3500	Basic Electricity	3500
Printer	49900	U.S. Government	3500	Basic Algebra	3500
Program Recorder	6900	Supervisory Skills	3500	**Basic Game and Program Cassettes**	
Software – ROM Cartridges		World History (Western)	35.00	Guide to BASIC Programming	1800
Education System Master Cartridge	2800	Basic Sociology	3500	BASIC Game Programs	1900
Atari BASIC	5500	Counseling Procedures	3500	**Add-On Memory**	
Assembler Debug	5500	Principles of Accounting	3500	8K RAM Memory Module	11000
Basketball	4200	Physics	3500	16K RAM Memory Module	22500
Life	4200	Great Classics (English)	3500	**Diskettes**	
Super Breakout™	4200	Business Communications	3500	Blank Diskettes	
Music Composer	5500	Basic Psychology	3500	Disk File Manager	500
Super Bug™	4200	Effective Writing	3500	**Accessory Controllers**	
Computer Chess	5500	Auto Mechanics	3500	Driving Controller Pair	1800
Home Finance	5500	Principles of Economics	3500	Paddle Controller Pair	1800
				Joystick Controller Pair	1800

SINGLE BOARD COMPUTER SELECTION GUIDE

BOARD	PROCESSOR	ACP PRICE	ENCLOSURE	BOARD	PROCESSOR	ACP PRICE	ENCLOSURE
DIG. RSCH. BIG BOARD	Z-80 64K	64900	N/A	SC-SBC100	Z80	23900	N/A
SYM-1	6502	23900	Add 3995	AIM 65	6502	375.00	Add 4995
Cromemco	Z80	40900	N/A	Cosmac Vip	1802	19900	Inc.

TEXAS INSTRUMENTS
INCORPORATED

99/4 PERSONAL COMPUTER

Superior Color, Music, Sound & Graphics – & a Powerful Extended Basic – All Built-In.

Now! Special T.V. Adapter lets you use your existing T.V. set as a computer display.

$499.00
Console only.

MATTEL ELECTRONICS® INTELLIVISION

ACP LOW PRICE
$259.95

GAME CARTRIDGES $26.95

BASEBALL	HOCKEY	POKER/BLACKJACK
FOOTBALL	BASKETBALL	ROULETTE
AUTO RACE	MOTOCROSS	HORSE RACING
TENNIS	ADVENTURE	SUB BATTLE
GOLF	CHECKERS	ARMOR BATTLE
SOCCER	CHESS	SPACE BATTLE
SKIING	MATH FUN	SEA BATTLE
BOXING	BACKGAMMON	ARCADE
BOWLING	WORD FUN	

RETAIL STORES OPEN MON-SAT

STORE #1: 1310 "B" E. Edinger, Santa Ana CA 92705 Showrooms, Retail, Warehouse
STORE #2: 674 El Camino Real, Tustin, CA 92660 Specializing in Systems
STORE #3: 542 W. Trimble Road, San Jose, CA 95131 • (408) 946-7010

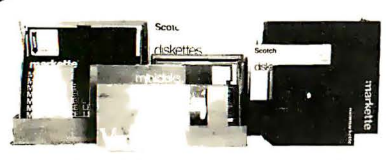
P.O. Box 17329 Irvine, Calif. 92713
Direct Order Lines: (714) 558-8813
(800) 854-8230 or (800) 854-8241

DRIVER'S LICENSE # OR MAJOR CREDIT CARD # IS REQUIRED ON ALL CHECKS. MONEY ORDER OR CASHIER CHECK WILL FACILITATE THE SHIPMENT OF YOUR PURCHASE.

Circle 7 on inquiry card.

California Digital

Post Office Box 3097 B • Torrance, California 90503



DISKETTES

FREE PLASTIC LIBRARY CASE INCLUDED WITH THE PURCHASE OF EVERY BOX OF DISKETTES

Private labeled for California Digital by one of the most respected producers of magnetic media. Each diskette is certified double density at 40 tracks. To insure extended media life each diskette is manufactured with a reinforced hub-hole. And of course, a plastic library case is included with every box of diskettes. MMD-CD5(01)(10) Please specify computer or required sectors.

$24.95 BOX

Ten boxes $22.75 One hundred boxes $21.50

MINIDISKETTES	Box	10 boxes		Box	10 boxes
Memorex 3401	$27.00	$25.00	Scotch 744(0)(10)(16)	$31.00	$29.00
Verbatim 525(01)(10)	29.00	27.00	Dysan	45.00	43.00

EIGHT INCH	Scotch	box	10 bx.	Dysan	box	10 bx.	MRX	box	10 bx.
Single side/single den.	740-0	$35.	$33.	3740/1	$49.	$47.	3060	$ 5.	$ 3.
Single side/double den.	741-0	45.	43.	3740/1d	75.	73.	3090	37.	35.
Single side/32 sector	740-32	35.	33.	na.			na.		
Double side/double D.	743-0	65.	59.	na.			3115	49.	45.

SCOTCH brand head cleaning kit. $24.95 MMA-CK(5)(8) please specify 5 1/4 8"

Prices available on request for: tape, cartridges, diskpacks, volumn diskettes.

MEMORY

TRS-80 APPLE II $25

16k memory (8) 4116's

Factory prime. Unconditionally guarenteed for one full year. Add $3.00 for TRS-80 jumpers and instructions.

DYNAMIC

		ea.	32+	100+	1K+
4116-	200ns	3.25	3.00	2.75	2.50
4116	150ns	3.75	3.50	3.25	3.00
4164 64K		49.50	45.00		

STATIC

21L02	450ns.	1.19	1.05	.99	
21L02	250ns	1.49	1.45	1.39	
2114L4	450ns	3.95	2.95	2.75	2.50
2114L3	300ns	4.25	3.75	3.00	2.75
4044-4	450ns	4.95	4.50	4.25	4.00
4044-2	250ns	5.50	4.95	4.50	4.35
5257-3	300ns	4.47	4.25	4.05	3.75

EPROM

2708	450ns	4.95	4.50	3.75	3.25
2716	5V.	7.95	6.50	5.00	4.50
2716	tri-volt	9.95	9.00	8.25	7.50
2732	Intel	19.00	17.50	16.00	
2532	TI	21.50	19.00		
2764		*			



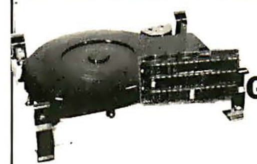
direct connect MODEM Your Choice **$169**

Direct connect modems eliminate loss of information due to the carbon compression associated with acoustic modems. Choose either of these two great units.

The Universal Data Systems 103LP is switch selectable between answer and originate modes. Fully Bell 103 compatable. Directly connects to the new modular telephone jack. 100% powered from the telephone line. No need to locate modem in proximity to A.C. power recepticle. MOD-103LP 2 pounds.

Novation "D" Cat connects to host of the new "Bell" modular handsets. Ideal for multiple line office telephones. Requires external A.C. power. MOD-DCAT 2 Lb.

UDS 103J/LP AUTO ANSWER $219



26 Megabyte Hard Disk Drive from GEORGE MORROW'S Thinker Toys $3950

Other Morrow Products.			
Additional hard disk	$3650	Disc Jockey 2D controller	$345
Discus 2D 1 drive	950	Disk Jockey I Controller	195
Discus 2D 2 drives	1627	M26 hard disk Controller	625
Discus 2+2 1 drive	1250	Switchboard interface	219
Discus 2+2 2 drives	2237	"New" Multiboard	275
		M-10 Ten Megabyte hard	2550

HEWLETT PACKARD $2650



The Hewlett Packard HP-85 is a complete, low cost portable computer system. This self contained package includes CPU, keyboard, printer, CRT display and cassette tape drive. SYS-HP85 30 lbs.



BSR SYSTEM X·10

The new BSR timer runs your home just like clockwork. Turns on lamps and appliances while your away from home. Completely compatible with your existing System X-10 devices.

BSR Timer eight channel	$65.00	Appliance Module 500 W.	$13.95
Master control console	34.95	Lamp Module 300 Watts	13.95
Ultrasonic Controller	19.95	NEW full control wall switch	14.50

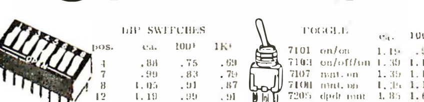
S-100 Mother Board $35

Quiet Buss

8803-18 18 slot IMSAI

The Quiet Buss from California Digital is quality engineered. No short cuts have been taken to produce this mother board. Active termination circuitry prevents noise and crosstalk. manufactured from extra heavy epoxy glass.

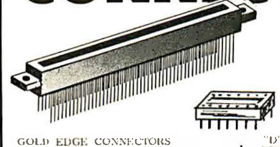
SWITCHES



DIP SWITCHES pos.	ea.	100+	1K+
4	.88	.75	.69
7	.99	.83	.79
8	1.05	.91	.87
12	1.19	.99	.91

TOGGLE		ea.	100+
7101	on/on	1.19	.98
7103	on/off/on	1.39	1.19
7107	mnt. on	1.39	1.19
7108	mnt. on	1.39	1.19
7205	dpdt mnt	1.85	1.65

CONNECTORS



GOLD EDGE CONNECTORS

S-100 .125" centers	each	10+
Imsai solder .250" row	$2.95	$2.50
Imsai wire wrap (TI)	3.95	3.50
Sullins Hi-Rel. .250"	4.50	4.00
Sullins Hi-Rel. W/W	5.35	4.90
Sullins /Altair .140"	4.95	4.50
.156" Centers (standard)		
22/44 Kim Eyelet	2.50	2.15
36/72 Digital Group S/T	5.95	5.50
36/72 Digital Group W/W	6.60	6.15
43/86 Motorola 6800S/T	6.60	6.15
43/86 Moto. 6800 W/W	7.00	6.85

INTEGRATED CIRCUIT SOCKETS

	Low Profile each	Low Profile 100+	Wire Wrap each	Wire Wrap 100+
8 pin	$.10	$.09	$.46	$.41
14 pin	.10	.09	.45	.41
16 pin	.12	.11	.50	.45
18 pin	.15	.13	.68	.61
24 pin	.26	.24	.94	.87
40 pin	.42	.40	1.60	1.47

"D" Type	each	10-24	25+
DE9P male	$1.60	$1.40	$1.30
DE9S female	2.25	2.00	1.90
DE hood	1.50	1.35	1.20
DA15P male	2.35	2.15	2.00
DA15S female	3.25	3.10	2.90
DA hood 2/P	1.60	1.35	1.30
DB25P male	2.50	2.35	2.25
DB25S female	3.35	3.15	3.05
DB hood 2/P	1.35	1.15	1.05
DC37P male	4.20	4.00	3.70
DC37S female	6.00	5.75	5.50
DC hood 2/P	2.25	2.00	1.75
DD50P male	5.50	5.10	4.75
DD50S female	9.40	8.60	8.00
DD50 hood 2/P	2.60	2.40	2.10
CENTRONICS			
57-30360	7.95	6.75	5.75
RIBBON CABLE CONNECTORS			
17/34 5" disk	4.85	4.15	3.95
20/40 TRS-80	5.65	5.05	4.70
25/50 8" disk	5.90	5.15	4.90

SPECIAL $295



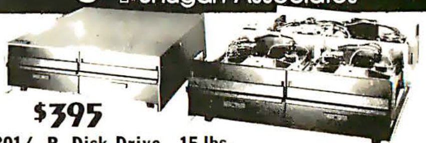
SHUGART SA800/1

Your Choice 115V. 60Hz or 230V. 50Hz.

These Shugart eight inch disk drives were originally purchased by major computer manufacturers. Upon failing incoming inspection the drives were sent back to Shugart for realigment.

California Digital has negotiated an extremely attractive agreement to purchase the entire inventory of the SA800's We are offering the drives on a first come basis at only $295. (Subject to remaining inventory on hand.) Installation manual $10 additional. Warranty 30 days from date of receipt. NOTE: The SA800/1 is standard mount and not the "R" suffix rack mount unit. SPC-800/115 or SPC-800/230 16 Lbs.

Shugart Associates



$395

801/ R Disk Drive 15 lbs.

Shugart 801/R with CP 206 power supply, muffin exhaust fan, complete in dual enclosure with all the necessary harnessing cables. Documentation included. 36 pounds. MSD-1801 **$795**

Same as above but with two Shugart 801R disk drives. 50 pounds. MSD-2801 **$1195**

Disk drive cable. 6 feet 50 conductor with edge card connector at both ends. WCA-650S $25.00

Export Disk drives. 220V. 50MHz add $50.00 per disk drive.

NEW from Shugart Technology 5 Megabyte Hard Disk Drive

Packaged in the same physical size as the industry standard 5 1/4" minifloppy disk drive. The micro-Winchester stores thirty times as much data (6.38 megabytes unformatted), accesses data twice as fast (170 milliseconds) and transfers data twenty times faster (5.0 megabits per second.)

The ST506 is factory sealed to protect the media from environmental contaminates. Requires only DC voltage.

Dual California Digital 5 1/4" enclosure, ST506 drive and power supply. **$1500**

Shugart Associates SA400 removable media disk drive for above package. add: **$300**

S-100 & Apple controller scheduled for spring release.



DATA INPUT TERMINAL

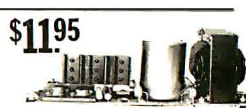
This Keystation terminal was recently acquired from the CMC division of the Pertec Corporation. The unit was originally designed for inputing data directly onto magnetic tape.

The system is comprised of a premium cast aluminium and fiberglass enclosure, along with a Honeywell / Microswitch hall effect keyboard. Thirty display lamps advise the operator of the systems status. Four inch loud speaker acknowledges acceptance of data and alerts the operator of pending problems.

But most of all this "USED" terminal, with a little imagination, can be engineered to make the perfect home for an S-100 computer and video display; or with slight modification will accept the Rockwell AIM-65 micro/computer.

Five volt regulated power supply is available for an additional $20. (see June Byte) All units are in excellent condition. Original acquisition over $700. 22 lbs.

Regulated Power Supply 5 VOLT 5 AMP **$11.95**



This USED surplus power supply was removed from working equipment. Pass transistor regulation outputs five volts at a conservative five amps. Suitable for TTL hobby applications. SPC-PS1 8 pounds.



All merchandise sold by California Digital is premium grade. Shipping: First five pounds $2.00; each additional add $.40 Foreign orders 10% shipping. Excess will be refunded. California residents add 6% sales tax. COD's discouraged. Open accounts extended to state supported educational institutions and companies with a "Strong Dun & Bradstreet." Warehouse: 15608 Inglewood Blvd. Visitors by appointment.

Circle 46 on inquiry card.

TOLL FREE ORDER LINE (800) 421-5041

TECHNICAL & CALIFORNIA (213) 679-9001

TWX 910 325-6212

California Digital

Post Office Box 3097 B • Torrance, California 90503



MEMOREX 8" DISKETTES

$25 WITH FREE LIBRARY CASE

Recently the Memorex Corporation had a cancellation on a contract for a truck load of eight inch diskettes. California Digital was fortunate to be offered this load of prime magnetic media.

These diskettes are "UNBRANDED" but are guaranteed first quality Memorex Brand. (#3060 single den.)

Like all diskettes sold by California Digital, a library case is supplied free with the purchase of every box.

This offer is subject to remaining inventory on hand.

SUPER BUY

World's Best Selling Printer

EPSON MX80

Immediate Delivery

Only $475

Correspondence quality printing.
A lot of printers costing a lot more can't touch the MX-80's performance. It gives you a choice of 40, 80, 66 or 132 columns of printing in as many as four distinct printing density modes, a total of twelve different combinations which can accommodate nearly any printing requirement.

Bidirectional printing. Logical seeking of shortest lines. 80 CPS. 64 graphics characters. Forms handling. The list of standard features goes on and on. The fact is that there are few printers that can compete with the MX-80 at ANY price. And none—ZERO—in its extraordinarily affordable price range.

ABCDEFGHIJKLMNOPQRSTUVWXYZABCDEFGHIJ

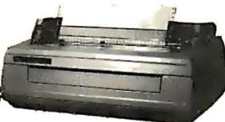


NEW from INTEGRAL DATA 460 Paper Tiger

with GRAPHICS $1150

The 460 Paper Tiger uses a dot matrix character formation technique in which the placement of the dots overlap both horizontally and vertically to achieve a correspondence quality printing.
The printer's nine-wire print head uses staggered needle rows to create the vertically overlapping dots. The head is driven bi-directionally under microprocessor control by a stepper motor driven mechanism.
"Two K" buffer allows the printer to accept the entire content of a 1,920 character CRT screen. With graphics suggested retail price $1,395 27 lbs. PRG-460G

NEC Spinwriter 5510P/S $2795



The word processing quality Spinwriter prints at speeds upto 55 characters per second. The Model 5510 P/S is supplied with both parallel and RS-232 serial interfacing. Also included is the tractor feed mechanism, along with print thimble and ribbon. PRN-5510 PS 70 lbs. Keyboard (KSR) Model 5520 P/S available $2995. PRN-5520 PS 75 lbs.



TEC V-300 Word Processing

Daisy Wheel Printer

$1595

Finally a reasonably priced letter quality printer... Bi-directional printing at 25 characters per second. Full 136 print positions wide. Proportional spacing 1/120" horizontal, 1/48" vertical.
Uses standard Diablo brand interchangable daisy print wheels.
Intel 8085 CPU microprocessor controlled. Interfaces via Centronics parallel connector. Shipping 58 lbs. PRV-300.

TELETYPE® MODEL 43

4320 KEYBOARD MODELS

TTL serial output	AAA	$ 995
RS232 serial	AAK	1050
Friction 80 column	AAE	1100
Friction 80 RS232	AAL	1195
Bell 103 Modem	AAB	1495



Ultra-Violet Products UVS 11-E

UV EPROM ERASER

$65



CENTRONICS

730 $595

737 $750



Both the Centronics 730 and the 737 are capable of accepting standard office letterhead or pin feed continuous forms. For higher resolution the 737 implements a nine wire dot matrix print head. Parallel interfacing. Add $65 for RS232. PRC-730P (S). PRC-737P (S) 17 lbs.

IBM 3101 Display Terminal

IBM Direct Price $1295

California Digital discount price $1195



AMPEX DIALOGUE 80 CRT TERMINAL

$995

New from the Ampex Corporation. The Dialogue 80 features removable keyboard, displayable two pages (four optional) dual program keys, half intensity protected fields and status line. Transmits data either block, line or character mode. Excellent value. VDT-D80 shipping 47 lbs.

VIDEO TERMINALS

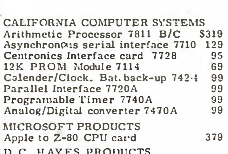
ADDS Regent 25 numeric cluster	VDT-R25	$850
ADDS Regent 30 25th status line	VDT-R30	950
ADDS Regent 40 limited graphics	VDT-R40	1195
ADDS Regent 60 Block mode	VDT-R60	1495
Ampex Dialouge 80 two page,detatch	VDT-D80	995
Digital Equipment VT-100	VDT-V100	1595
Digital Equipment VT-132	VDT-V132	1895
Direct VP-800A emulator	VDT-P800	call
Hazeltine 1410	VDT-H1410	750
Hazeltine 1420	VDT-H1420	795
Hazeltine 1500	VDT-H1500	850
Hazeltine 1510	VDT-H1510	1025
Hazeltine 1520	VDT-H1520	1225
Hewlett Packard 2621A	VDT-HP21A	
Hewlett Packard 2621P	VDT-HP21P	
IBM 3101-10 character mode green	VDT-3101	1195
IBM 3101-20 block mode	VDT-31012	1395
Lear Seigler 3A upper case only	VDT-L3A	850
Lear Seigler ADM5	VDT-L5	945
Lear Seigler ADM31	VDT-L31	1385
Lear Seigler ADM42	VDT-L42	1995
Soroc IQ 120	VDT-Q120	675
Soroc IQ 135 NEW	VDT-Q135	850
Soroc IQ 140 detatchable keyboard	VDT-Q140	1150
Televideo 912C	VDT-T912	665
Televideo 920C	VDT-T920	745
Televideo 950C detatchable keybd.	VDT-T950	985
Zenith Z-19	VDT-Z-19	735

VIDEO MONITORS



BMC KG12C 18MHz P-31 grn phosphor	$259
Leedex/Amdek 12"100	129
Leedex 100 green	169
Leedex 100-80	197
Hitachi color 13"	389
Zenith color 13"	379
NEC green phosphor	219
Panasonic color 10"	
Sanyo 9" BW	149
Sanyo 12" green phos.	235
Sanyo 15" BW	259
Sanyo 13" color	419

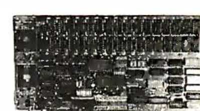
ACCESSORIES FOR THE APPLE COMPUTER



CALIFORNIA COMPUTER SYSTEMS	
Arithmetic Processor 7811 B/C	$319
Asynchronous serial interface 7710	129
Centronics Interface card 7728	95
12K PROM Module 7114	69
Calender/Clock. Bat. back-up 7424	99
Parallel Interface 7720A	99
Programable Timer 7740A	99
Analog/Digital converter 7470A	99
MICROSOFT PRODUCTS	
Apple to Z-80 CPU card	379
D. C. HAYES PRODUCTS	
Micromodem for Apple	319
COMPUTER STOP PRODUCTS	
Double Vision / 80 Column Video	250
INTERACTIVE STRUCTURES	
16 Channel A/D card AIO/2	275
MOUNTAIN COMPUTER PRODUCTS	
Intro X-10 system for BSR	$239
Intro X-10 card only	165
16 channel AD/DA 8 bit	319
Apple Clock battery back-up	225
Supertalker SD200	245
ROM Plus with filter	165
ROM Writer/Programmer	149
APPLE BRAND PRODUCTS	
Apple Language card	450
Floppy disk with controller	560
Floppy disk without controller	495
Apple parallel interface	175
SSM MICROCOMPUTER	
Dual serial parallel interface AIO	
SORRENTO VALLEY ASSOCIATES	
8" floppy controller (Pascal)	360

S-100 BOARDS

Assembled • Tested • Burned-in





CPU BOARDS		
Calif. Computer 2810A Z-80 DMA. 4MHz	BDC-C2810	$250
Godbout Z-80 24 bit. 4MHz	BDC-G280	239
Godbout 8085/8088 dual 16 bit processor	BDC-G88	375
Measurement Systems Z-80 4 serial 2 parallel real time clock, 8 vector	BDC-MZ80	395
SD Systems SBC-200 Z-80 with serial & parallel I/O ports	BDC-SBC2	385
Teletek FDC-1 single board CPU & floppy disk controller plus I/O	BDC-FDC1	695
MAINFRAMES		
Calif. Computer 2200A 12 slot & power supply	ENM-C2200	349
TEI 12 slot table	ENM-T12	495
TEI 22 slot table	ENM-T22	650
Godbout mainfrm.	ENM-GMF	
MEMORY BOARDS		
Calif. Computer 2065A 64K dynamic memory	BDM-C2065	$429
Calif. Computer 2016 16K static memory	BDM-C2016	259
Calif. Computer 2032 32K static memory	BDM-C2032	585
Godbout Ram 17 64K static memory 16 bit	BDM-G17	1025
SD Systems Expandoram II 16K dynamic	BDM-EX16	295
64K dynamic	BDM-EX64	375
Measurement Systems DMB6400 for Alpha Micro	BDM-M6400	685
EPROM BOARDS		
Digital Research 32K, 2716 proms extra	BDM-DP32	99
SD Systems Prom-100 programmer	BDM-P100	250
FLOPPY DISK CONTROLLER		
Calif. Computer 2422A with 2.2 CPM	BDF-C2422	329
Godbout "Disk One" features the NEC 765 controller. DMA arbitration	BDF-GD1	395
Measurement Systems 765 chip, single & double density. Error recovery	BDF-MF	419
SD Systems Versafloppy II double density	BDF-VF2	419
Tarbell D/D	BDF-TF2	419
Morrow Design Disk Jockey I single density	BDF-DJ1	195
Morrow Design Disk Jockey II double density	BDF-DJ2	345
INTERFACE BOARDS		
Calif. Computer 2718 I/O 2 serial/2 par'l	BDT-C2718	
Morrow Designs Switchboard 2 serial/4 parl	BDT-MSB	219
Morrow Designs Multiboard 3 serial/3P. +++	BDT-MMB	275
Godbout Interfacer One 2 serial/2 par'l	BDS-GE1	199
Godbout Interfacer Two 1 serial/3 par'l	BDS-GB2	199
SPECIALITY BOARDS		
QT Computer real time clock/calendar	BDS-QCK	135
Artec Elec. Wire wrap prototype board	BDS-AWW	25
Artec Elec. General Purpose proto board	BDS-AGP	25
Godbout Spectrum color board	BDS-GSC	295
D.C. Hayes S-100 Micromodem	BDS-HMI	350
Mullen Products extender board & logic probe kt	BDS-MTB1	49
Mullen Products Opto-contro board kit	BDS-MOC	139

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SN7402N	.25
SN7403N	.25
SN7404N	.25
SN7405N	.29
SN7406N	.35
SN7407N	.29
SN7408N	.29
SN7409N	.29
SN7410N	.25
SN7411N	.29
SN7412N	.35
SN7413N	.40
SN7414N	.69
SN7416N	.29
SN7417N	.29
SN7420N	.25
SN7421N	.29
SN7422N	.45
SN7423N	.29
SN7425N	.29
SN7426N	.29
SN7427N	.25
SN7428N	.49
SN7430N	.25
SN7432N	.29
SN7437N	.25
SN7438N	.40
SN7439N	.25
SN7440N	.20
SN7441N	.89
SN7442N	.59
SN7443N	1.10
SN7444N	1.10
SN7445N	.89
SN7446N	.79
SN7447N	.69
SN7448N	.79
SN7450N	.20
SN7451N	.20
SN7453N	.20
SN7454N	.20
SN7459A	.25
SN7460N	.20
SN7470N	.29
SN7472N	.29
SN7473N	.35
SN7474N	.35
SN7475N	.49
SN7476N	.35
SN7479N	5.00
SN7480N	.50
SN7482N	.99
SN7483N	.69
SN7485N	.89
SN7486N	.35
SN7489N	1.75
SN7490N	.49
SN7491N	.59
SN7492N	.45
SN7493N	.45
SN7494N	.69
SN7495N	.69
SN7496N	.69
SN7497N	3.00
SN74100N	1.49
SN74107N	.35
SN74109N	.39
SN74116N	1.95
SN74121N	.39
SN74122N	.55
SN74123N	.59
SN74125N	.49
SN74126N	.49
SN74132N	.75
SN74136N	.75
SN74141N	.99
SN74142N	3.25
SN74143N	3.49
SN74144N	3.49
SN74145N	.79
SN74147N	1.95
SN74148N	1.29
SN74150N	1.25
SN74151N	.69
SN74152N	.69
SN74153N	.79
SN74154N	1.25
SN74155N	.79
SN74156N	.79
SN74157N	.69
SN74160N	.89
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SN74162N	.89
SN74163N	.89
SN74164N	.89
SN74165N	.89
SN74166N	1.25
SN74167N	2.79
SN74170N	1.95
SN74172N	4.95
SN74173N	1.39
SN74174N	.99
SN74175N	.89
SN74176N	.79
SN74177N	.79
SN74179N	1.49
SN74180N	.79
SN74181N	2.25
SN74182N	.79
SN74184N	2.49
SN74185N	2.49
SN74190N	1.25
SN74191N	1.25
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SN74193N	.89
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SN74195N	.69
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SN74197N	.89
SN74198N	1.49
SN74199N	1.49
SN74221N	1.25
SN74251N	.99
SN74276N	1.95
SN74279N	.79
SN74283N	1.49
SN74284N	3.95
SN74285N	3.95
SN74365N	.69
SN74366N	.69
SN74367N	.69
SN74368N	.69
SN74390N	1.49
SN74393N	1.49

74LS

Part	Price
74LS00	.29
74LS01	.29
74LS02	.29
74LS03	.29
74LS04	.35
74LS05	.35
74LS08	.29
74LS09	.35
74LS10	.29
74LS11	.75
74LS12	.35
74LS13	.59
74LS14	.99
74LS15	.35
74LS20	.29
74LS21	.35
74LS22	.35
74LS26	.35
74LS27	.35
74LS28	.35
74LS30	.29
74LS32	.35
74LS33	.59
74LS37	.45
74LS38	.49
74LS40	.35
74LS42	.89
74LS47	.89
74LS48	1.15
74LS49	1.15
74LS51	.29
74LS54	.29
74LS55	.29
74LS73	.45
74LS74	.45
74LS75	.59
74LS76	.45
74LS78	.49
74LS83	.89
74LS85	1.25
74LS86	.45
74LS90	.59
74LS92	.75
74LS93	.75
74LS95	.99
74LS96	1.15
74LS107	.45
74LS109	.45
74LS112	.45
74LS113	.49
74LS114	.49
74LS122	.89
74LS123	1.25
74LS125	.89
74LS126	.55
74LS132	.99
74LS133	.49
74LS136	.49
74LS138	.89
74LS139	.89
74LS151	.89
74LS153	.89
74LS154	1.75
74LS155	1.19
74LS156	1.19
74LS157	.89
74LS158	.99
74LS160	1.15
74LS161	1.15
74LS162	1.15
74LS163	1.15
74LS164	1.25
74LS165	1.25
74LS168	1.19
74LS169	1.19
74LS170	2.49
74LS173	1.39
74LS174	.99
74LS175	.99
74LS181	2.95
74LS190	1.25
74LS191	1.25
74LS192	1.15
74LS193	1.15
74LS194	1.15
74LS195	1.15
74LS197	1.19
74LS221	1.19
74LS240	1.95
74LS241	1.95
74LS242	1.95
74LS243	1.95
74LS244	1.95
74LS245	2.95
74LS247	1.19
74LS248	1.19
74LS249	1.19
74LS251	1.49
74LS253	.89
74LS257	.89
74LS258	.99
74LS260	.69
74LS266	.69
74LS273	1.95
74LS279	.75
74LS283	1.09
74LS290	.99
74LS293	.99
74LS298	1.25
74LS352	1.29
74LS353	1.29
74LS365	.75
74LS366	.75
74LS367	.75
74LS368	.75
74LS373	1.95
74LS374	1.95
74LS375	.89
74LS386	.69
74LS393	2.49
74LS399	2.49
74LS670	2.49
81LS95	1.95
81LS97	1.95

74S

Part	Price
74S00	.50
74S02	.50
74S03	.50
74S04	.55
74S05	.55
74S08	.50
74S09	.50
74S10	.50
74S11	.50
74S15	.50
74S20	.50
74S22	.50
74S30	.50
74S32	.55
74S40	.55
74S51	.50
74S64	.50
74S65	.50
74S74	.79
74S86	.79
74S112	.79
74S113	.79
74S114	.79
74S133	.55
74S134	.69
74S135	1.19
74S136	1.75
74S138	1.35
74S139	1.35
74S140	1.15
74S151	1.35
74S153	1.35
74S157	1.35
74S158	1.35
74S174	1.59
74S175	1.59
74S188	4.95
74S194	1.95
74S195	1.95
74S196	3.95
74S240	2.95
74S241	2.95
74S242	3.25
74S243	3.25
74S244	3.25
74S251	1.45
74S253	1.45
74S257	1.35
74S258	1.35
74S260	.79
74S280	2.95
74S287*	4.95
74S288*	4.95
74S373	3.49
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74S572*	19.95
74S573*	19.95
74S940	3.15
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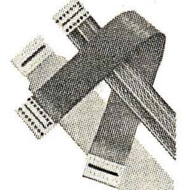
Part	Price
CA3013H	2.15
CA3023H	3.25
CA3039H	1.35
CA3046N	1.30
CA3059N	3.25
CA3060N	3.25
CA3080H	1.25
CA3081N	2.00
CA3082N	2.00
CA3083N	1.60
CA3086N	.85
CA3089N	3.75
CA3096N	3.95
CA3130H	1.39
CA3140H	1.25
CA3160H	1.25
CA3401N	.59
CA3600N	3.50

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Part	Price
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CD4001	.39
CD4002	.39
CD4006	1.19
CD4007	.25
CD4009	.49
CD4010	.49
CD4011	.39
CD4012	.25
CD4013	.49
CD4014	1.39
CD4015	1.19
CD4016	.59
CD4017	1.19
CD4018	.99
CD4019	.49
CD4020	1.19
CD4021	1.39
CD4022	1.19
CD4023	.29
CD4024	.79
CD4025	.23
CD4026	2.95
CD4027	.69
CD4028	.89
CD4029	1.49
CD4030	.49
CD4035	.99
CD4040	1.49
CD4041	1.49
CD4042	.99
CD4043	.89
CD4044	.89
CD4046	1.79
CD4047	2.50
CD4048	1.35
CD4049	.49
CD4050	.69
CD4051	1.19
CD4052	1.19
CD4053	1.19
CD4056	2.95
CD4059	9.95
CD4060	1.49
CD4066	.79
CD4068	.39
CD4069	.45
CD4070	.55
CD4071	.49
CD4072	.49
CD4073	.39
CD4075	.39
CD4076	1.39
CD4078	.39
CD4081	.39
CD4082	.39
CD4093	.99
CD4098	2.49
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CD4508	3.95
CD4510	1.39
CD4511	1.29
CD4514	3.95
CD4515	2.95
CD4516	1.49
CD4518	1.79
CD4519	.89
CD4520	1.29
CD4526	1.79
CD4528	1.19
CD4543	2.79
CD4562	11.95
CD4566	2.79
CD4583	2.49
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MC14412	11.95
MC14419	4.95
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- Mate with Standard IC Sockets
- Fully Assembled and Tested
- Integral Molded-On Strain Relief
- Line-By-Line Probeability

DipJumpers are used for jumpering within a PC Board; interconnecting between PC Boards, backplanes and mother boards; and interfacing input/output signals.

Part Number	No. of contacts	Description	Wire Length	Price
924102-12	14	single end	12"	$1.51
924102-24	14	single end	24"	1.92
924102-36	14	single end	36"	2.33
924106-12	14	double end	12"	2.61
924106-24	14	double end	24"	3.02
924106-36	14	double end	36"	3.43
924112-12	16	single end	12"	1.67
924112-24	16	single end	24"	2.13
92411236	16	single end	36"	2.59
924116-12	16	double end	12"	2.88
924116-24	16	doubleend	24"	3.34
924116-36	16	doubleend	36"	3.80
924122-12	24	singleend	12"	2.60
924122-24	24	singleend	24"	3.30
924122-36	24	single end	36"	4.00
924126-12	24	double end	12"	4.50
924126-24	24	double end	24"	5.20
924126-36	24	doubleend	36"	5.90
924132-12	40	single end	12"	4.35
924132-24	40	single end	24"	5.53
924132-36	40	single end	36"	6.71

DISCRETE LEDS

Part	Size	Color	Price
XC556R	.200"	red	5/$1
XC556G	.200"	green	4/$1
XC556Y	.200"	yellow	4/$1
XC556C	.200"	clear	4/$1
XC22R	.200"	red	5/$1
XC22G	.200"	green	4/$1
XC22Y	.200"	yellow	4/$1
MV10B	.170"	red	4/$1
MV50	.085"	red	6/$1
XC209R	.125"	red	5/$1
XC209G	.125"	green	4/$1
XC209Y	.125"	yellow	4/$1
XC526R	.185"	red	5/$1
XC526G	.185"	green	4/$1
XC526Y	.185"	yellow	4/$1
XC526C	.185"	clear	4/$1
XC111R	.190"	red	5/$1
XC111G	.190"	green	4/$1
XC111Y	.190"	yellow	4/$1
XC111C	.190"	clear	4/$1

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DISPLAY LEDS

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Type	Polarity	Ht	Price
MAN 1	C.A.—red	.270	2.95
MAN 2	5x7 D.M.—red	.300	4.95
MAN 3	C.C.—red	.125	.25
MAN 52	C.A.—green	.300	1.25
MAN 54	C.C.—green	.300	1.25
MAN 71	C.A.—red	.300	.75
MAN 72	C.A.—red	.300	.75
MAN 74	C.C.—red	.300	1.25
MAN82	C.A.—yellow	.300	.49
MAN 84	C.C.—yellow	.300	.99
MAN 3620	C.A.—orange	.300	.49
MAN 3630	C.A.—orange ± 1	.300	.99
MAN 3640	C.C.—orange	.300	.99
MAN 4610	C.A.—orange	.400	.99
MAN 6610	C.A.—orange—DD	.560	.99
MAN 6630	C.A.—orange ± 1	.560	.99
MAN 6640	C.C.—orange—DD	.560	.99
MAN 6650	C.C.—orange ± 1	.560	.99
MAN 6660	C.A.—orange	.560	.99
MAN 6710	C.A.—red—DD	.560	.99
MAN 6750	C.C.—red ± 1	.560	.99
MAN 6780	C.C.—red	.560	.99
DLO304	C.C.—orange	.300	1.25
DLO307	C.A.—orange	.300	1.25
DLG500	C.C.—green	.500	1.25
DLG507	C.A.—green	.500	1.25
DL704	C.C.—red	.300	1.25
DL707	C.A.—red	.300	1.25
DL728	C.C.—red	.500	1.49
DL741	C.A.—red	.600	1.25
DL746	C.A.—red ± 1	.630	1.49
DL747	C.A.—red	.600	1.49
DL750	C.C.—red	.600	1.49
DLO847	C.A.—orange	.800	1.49
DLO850	C.C.—orange	.800	1.49
DL33B	C.C.—red	.110	.35
FND358	C.C. ± 1	.357	.99
FND359	C.C.	.357	.75
FND503	C.C. (FND500)	.500	.99
FND507	C.A. (FND510)	.500	.99
HDSP-3401	C.A.—red	.800	1.50
HDSP-3403	C.C.—red	.800	1.50
5082-7751	C.A.,R.H.D.—red	.430	1.25
5082-7760	C.C.,R.H.D.—red	.430	1.75
5082-7300	4x7sgl. dig. RHD	.600	22.00
5082-7302	4x7sgl. dig. LHD	.600	22.00
5082-7304	Overnge. char.(±1)	.600	19.95
4N28	Photo XsistorOpto-Isol.		.99
LIT-1	Photo Xsistor Opto-Isol.		.69
MOC3010	Optically Isol.Triac Driver		1.25

SOCKETS — Test TEXTOOL Sockets — RECEPTACLES



ZERO INSERTION FORCE

- Nickel Boron Plating
- G.F. PSF Plastic Body
- For testing IC's

PartNo.	Pins	Price
214-3339	14 pin	5.95
216-3340	16 pin	6.49
218-3341	18 pin	7.95
220-3342	20 pin	8.95
222-3343	22 pin	9.95
224-3344	24 pin	9.75
228-3345	28 pin	11.95
240-3346	40 pin	12.95

- Nickel Boron Plating
- G.F. PSF Plastic Body
- Wire Wrap Contacts

PartNo.	Pins	Price
214-3592	14 pin	9.75
216-3593	16 pin	9.95
218-3594	18 pin	10.95
220-3595	20 pin	11.95
222-3596	22 pin	12.95
224-3597	24 pin	12.75
228-3598	28 pin	13.95
240-3599	40 pin	15.95

LOW PROFILE (TIN) SOCKETS

	1-24	25-49	50-100
8 pin LP	.17	.16	.15
14 pin LP	.20	.19	.18
16 pin LP	.22	.21	.20
18pin LP	.29	.28	.27
20 pin LP	.34	.32	.30
22 pin LP	.37	.36	.35
24 pin LP	.38	.37	.36
28 pin LP	.45	.44	.43
36 pin LP	.60	.59	.58
40 pin LP	.63	.62	.61

SOLDERTAIL STANDARD (TIN)

	1-24	25-49	50-100
14 pin ST	.27	.25	.24
16 pin ST	.30	.27	.25
18 pin ST	.35	.32	.30
24 pin ST	.49	.45	.42
28 pin ST	.99	.90	.81
36 pin ST	1.39	1.26	1.15
40 pin ST	1.59	1.45	1.30

SOLDERTAIL (GOLD) STANDARD

	1-24	25-49	50-100
8 pin SG	.39	.35	.31
14 pin SG	.49	.45	.41
16 pin SG	.54	.49	.44
18 pin SG	.59	.53	.48
24 pin SG	.79	.75	.69
28 pin SG	1.10	1.00	.90
36 pin SG	1.65	1.40	1.26
40 pin SG	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

	1-24	25-49	50-100
8 pin WW	.59	.54	.49
10 pin WW	.69	.63	.58
14 pin WW	.79	.73	.67
16 pin WW	.85	.77	.70
18 pin WW	.99	.90	.81
20pin WW	1.19	1.08	.99
22 pin WW	1.49	1.35	1.23
24 pin WW	1.39	1.26	1.14
28 pin WW	1.69	1.53	1.38
36 pin WW	2.19	1.99	1.79
40 pin WW	2.29	2.09	1.89

1/4 WATT RESISTOR ASSORTMENTS – 5%

Asst.		Values		Price
ASST. 1	5ea.	10 Ohm 12 Ohm 15 Ohm 18 Ohm 22 Ohm 27 Ohm 33 Ohm 39 Ohm 47 Ohm 56 Ohm	50pcs.	$1.95
ASST. 2	5ea.	68 Ohm 82 Ohm 100 Ohm 120 Ohm 150 Ohm 180 Ohm 220 Ohm 270 Ohm 330 Ohm 390 Ohm	50pcs.	$1.95
ASST. 3	5ea.	470 Ohm 560 Ohm 680 Ohm 820 Ohm 1K 1.2K 1.5K 1.8K 2.2K 2.7K	50pcs.	$1.95
ASST. 4	5ea.	3.3K 3.9K 4.7K 5.6K 6.8K 8.2K 10K 12K 15K 18K	50pcs.	$1.95
ASST. 5	5ea.	22K 27K 33K 39K 47K 56K 68K 82K 100K 120K	50pcs.	$1.95
ASST. 6	5ea.	150K 180K 220K 270K 330K 390K 470K 560K 680K 820K	50pcs.	$1.95
ASST. 7	5ea.	1M 1.2M 1.5M 1.8M 2.2M 2.7M 3.3M 3.9M 4.7M 5.6M	50pcs.	$1.95
ASST. 8R		Includes Resistor Assts. 1-7 (350 pcs.)		$10.95 ea.

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6/81

INTERSIL

Part No.	Function	Price
7045IPI	CMOS Precision Timer	14.95
7045EV/Kit*	Stopwatch Chip, XTL	22.95
7106CPL	3½ Digit A/D (LCD Drive)	16.95
7106EV/Kit*	IC, Circuit Board, Display	34.95
7107CPL	3½ Digit A/D (LED Drive)	15.95
7107EV/Kit*	IC, Circuit Board, Display	28.95
7116CPL	3½ Digit A/D LCD Dis. HLD.	18.95
7117CPL	3½ Digit A/D LED Dis. HLD.	17.95
7201IDR	Low Battery Volt Indicator	2.25
7205IPG	CMOS LED Stopwatch/Timer	12.95
7205EV/Kit*	Stopwatch Chip, XTL	19.95
7206CJPE	Tone Generator	5.15
7206CEV/Kit*	Tone Generator Chip, XTL	9.95
7207AIPD	Oscillator Controller	6.50
7207AEV/Kit*	Freq. Counter Chip, XTL	11.10
7208IPI	Seven Decade Counter	17.95
7209IPA	Clock Generator	3.95
7215IPG	4 Func. CMOS Stopwatch CKT	13.95
7215EV/Kit*	4 Func. Stopwatch Chip, XTL	19.95
7216AIJI	8-Digit Univ. Counter C.A.	32.00
7216CIJI	8-Digit Freq. Counter C.A.	26.95
7216DIPI	8-Digit Freq. Counter C.C.	21.95
7217IJI	4-Digit LED Up/Down Counter	12.95
7218CIJI	8-Digit Univ. LED Drive	10.95
7224IPL	LCD 4½ Digit Up Counter DRI	11.25
7226AIJL	8-Digit Univ. Counter	31.95
7226AEV/Kit*	5 Function Counter Chip, XTL	74.95
7240IJE	CMOS Bin Prog. Timer/Counter	4.95
7242IJA	CMOS Divide-by-256 RC Timer	2.05
7250IJE	CMOS BCD Prog. Timer/Counter	6.00
7260IJE	CMOS BCD Prog. Timer/Counter	5.25
7555IPA	CMOS 555 Timer (8 pin)	1.45
7556IPD	CMOS 556 Timer (14 pin)	2.20
7611BCPA	CMOS Op Amp Comparator 5MV	2.25
7612BCPA	CMOS Op Amp Ext. Cmvr. 5MV	2.95
7621BCPA	CMOS Dual Op Amp Comp. 5MV	3.95
7631CCPE	CMOS Tri Op Amp Comp. 10MV	5.35
7641CCPD	CMOS Quad Op Amp Comp. 10MV	7.50
7642CCPD	CMOS Quad Op Amp Comp. 10MV	7.50
7660CPA	Voltage Converter	2.95
8069CCQ	50ppm Band—GAP Volt Ref. Diode	2.50
8211CPA	Volt Ref/Indicator	2.50
8212CPA	Volt Ref/Indicator	2.50

* INTERSIL'S EVALUATION KITS

74C

Part	Price
74C00	.39
74C02	.39
74C04	.39
74C08	.39
74C10	.39
74C14	.75
74C20	.39
74C30	.39
74C42	1.39
74C48	1.95
74C73	.79
74C74	.79
74C85	1.95
74C86	.99
74C89	6.95
74C90	1.29
74C93	1.29
74C95	1.59
74C106	.75
74C107	1.89
74C151	2.95
74C154	3.95
74C157	2.25
74C160	1.69
74C161	1.60
74C162	1.49
74C163	1.69
74C164	1.59
74C173	1.39
74C174	1.39
74C175	1.39
74C192	1.69
74C193	1.69
74C195	1.59
74C221	1.95
74C240	2.25
74C244	2.25
74C373	2.49
74C374	2.59
74C901	.89
74C903	1.15
74C911	10.95
74C912	10.95
74C915	1.69
74C917	10.95
74C922	5.49
74C923	5.75
74C925	7.50
74C926	7.50
80C95	.79
80C97	.79

LINEAR

Part	Price
LH0002CN	6.85
LM10CLH	4.50
LM11CLH	4.75
LH0070-0H	6.05
TL071CP	.79
TL072CP	1.39
TL074CN	2.49
LH0082CD	35.80
TL082CP	1.19
TL084CN	2.19
LH0094CD	36.80
LM300H	.99
LM301CN	.35
LM302H	1.95
LM304H	1.95
LM305H	.99
LM307CN	.45
LM308CN	1.00
LM309H	1.95
LM309K	1.25
LM310CN	1.75
LM311H	.90
LM312H	2.49
LM317MP	1.15
LM317T	1.75
LM317K	3.95
LM318CN	1.95
LM319N	1.95
LM320K-5	1.35
LM320K-12	1.35
LM320K-15	1.35
LM320T-5	1.25
LM320T-12	1.25
LM320T-15	1.25
LM323K-5	5.95
LM324N	.99
LM329DZ	.65
LM331N	3.95
LM334Z	1.30
LM335Z	1.40
LM336Z	1.75
LM337T	1.95
LM337MP	1.15
LM338K	6.95
LM339N	.99
LM340K-5	1.35
LM340K-12	1.35
LM340K-15	1.35
LM340T-5	1.25
LM340T-12	1.25
LM340T-15	1.25
LM341P-5	.75
LM341P-12	.75
LM341P-15	.75
LM342P-5	.69
LM342P-12	.69
LM342P-15	.69
LM348N	1.25
LM350K	5.75
LF351N	.60
LF353N	1.00
LF355N	1.10
LF356N	1.10
LM358N	1.00
LM359N	1.79
LM370N	4.49
LM373N	3.25
LM377N	2.95
LM380N	1.25
LM381N	1.95
LM382N	1.79
LM384N	1.95
LM386N-3	1.29
LM387N	1.45
LM389N	1.35
LM392N	.69
LF398N	4.00
LM399H	5.00
TL494CN	4.49
TL496CP	1.75
NE510A	6.00
NE529A	4.95
NE531H	3.95
NE536H	6.00
NE540H	6.00
NE544N	4.95
NE550A	1.30
NE555V	.39
LM556N	.99
NE564N	3.95
LM565N	1.25
LM566CN	1.95
LM567V	1.25
NE570N	4.95
LM702H	.79
LM703CN	.89
LM709N	.49
LM710N	.79
LM711N	.79
LM723N	.69
LM733N	1.00
LM739N	1.19
LM741CN	.35
MC1741SCG	3.00
LM747N	.79
LM748N	.59
LM1014N	2.75
LM1310N	1.95
LM1458CN	.59
LM1488N	1.25
LM1489N	1.25
LM1496N	1.95
LM1556V	1.75
LM1800N	2.95
LM1877N-9	3.25
LM1889N	3.20
LM1896N	1.75
LM2002T	1.49
LM2877P	2.05
LM2878P	2.25
LM2896P-1	2.25
LM3189N	2.95
LM3900N	.69
LM3905CN	1.25
LM3909N	1.15
LM3914N	3.95
LM3915N	3.95
LM3916N	3.95
RC4136N	1.25
RC4151NB	3.95
RC4194TK	5.95
RC4195TK	5.49
KB4428	4.25
KB4429	5.95
LM4500A	3.25
ICL8038B	4.95
LM13080N	1.29
LM13600N	1.49
75138N	1.95
75450N	.89
75451CN	.39

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

Value	1-9	10-99	100+	Value	1-9	10-99	100+
10 pf	.08	.06	.05	.001µF	.08	.06	.05
22 pf	.08	.08	.05	.0047µF	.08	.06	.05
47 pf	.08	.08	.05	.01µF	.08	.06	.05
100 pf	.08	.06	.05	.022µF	.09	.07	.06
220 pf	.08	.06	.05	.047µF	.09	.07	.06
470 pf	.08	.06	.05	.1µF	.15	.12	.10

100 VOLT MYLAR FILM CAPACITORS

Value	1-9	10-99	100+	Value	1-9	10-99	100+
.001mf	.12	.10	.07	.022mf	.13	.11	.08
.0022mf	.12	.10	.07	.047mf	.21	.17	.13
.0047mf	.12	.10	.07	.1mf	.27	.23	.17
.01mf	.12	.10	.07	.22mf	.33	.27	.22

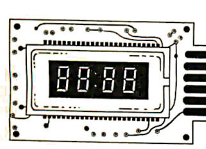
+20% DIPPED TANTALUMS (Solid) CAPACITORS

Value	1-9	10-99	100+	Value	1-9	10-99	100+
.1/35V	.39	.34	.29	1.5/35V	.41	.37	.29
.15/35V	.39	.34	.29	2.2/35V	.51	.45	.34
.22/35V	.39	.34	.29	3.3/25V	.53	.47	.37
.33/35V	.39	.34	.29	4.7/25V	.63	.56	.45
.47/35V	.39	.34	.29	6.8/25V	.79	.69	.55
.68/35V	.39	.34	.29	15/25V	1.39	1.25	.95
1.0/35V	.39	.34	.29	22/6V	.79	.69	.55

MINI. ALUMINUM ELECTROLYTIC CAPACITORS

Axial	1-99	100-499	500+	Radial	1-99	100-499	500+
.47/50V	.16	.14	.10	.47/25V	.15	.13	.12
1.0/50V	.19	.16	.12	.47/50V	.16	.14	.13
3.3/50V	.17	.15	.11	1.0/16V	.15	.13	.12
4.7/25V	.18	.15	.11	1.0/25V	.16	.14	.13
10/25V	.18	.15	.11	1.0/50V	.17	.15	.14
10/50V	.19	.16	.12	4.7/16V	.15	.13	.12
22/25V	.19	.16	.12	4.7/25V	.16	.14	.13
22/50V	.24	.20	.18	4.7/50V	.17	.15	.14
47/25V	.25	.21	.19	10/16V	.15	.13	.12
47/50V	.29	.25	.23	10/25V	.16	.14	.13
100/25V	.28	.24	.22	10/50V	.17	.15	.14
100/50V	.41	.37	.34	47/50V	.25	.21	.19
220/25V	.39	.34	.33	100/16V	.21	.17	.14
220/50V	.49	.45	.41	100/25V	.25	.23	.21
470/25V	.54	.49	.45	100/50V	.37	.34	.31
1000/16V	.79	.69	.61	220/16V	.25	.21	.19
2200/16V	.89	.79	.69	470/25V	.35	.31	.27

National Semiconductor Clock Modules



12VDC AUTOMOTIVE/ INSTRUMENT CLOCK

APPLICATIONS:
- In-dash autoclocks
- After-market auto/ RV clocks
- Aircraft-marine clks.
- 12VDC oper. instru.
- Portable/battery powered instrumnts.

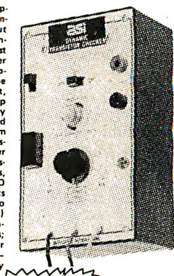
Features: Bright 0.3" green display. Internal crystal time-base. ± 0.5 sec./day accur. Auto. display brightness control logic. Display color filterable to blue, blue-green, green & yellow. Complete—just add switches and lens.

MA1003 Module $16.95

CLOCK MODULES		
MA1023	.7" Low Cost Digital LED Clock Module	8.95
MA1026	.7" Dig. LED Alarm Clock/Thermometer	18.95
MA5036	.3" Low Cost Digital LED Clock/Timer	6.95
MA1002	.5" LED Display Dig. Clock & Xformer	9.95
TRANSFORMERS		
XFMR1023	Xformer for MA1023 Clock Modules	3.49
XFMR1026	Xformer for MA1026 Clock Modules	3.49
XFMR5036	Xformer for MA5036 Clock Modules	3.49

Transistor Checker

The *ASI Transistor Checker* is capable of checking a wide range of transistor types, either "in circuit" or out of circuit. It has been specially designed to take advantage of the newest concept of dynamic testing under current amplifier conditions. To operate, simply plug the transistor to be checked into the front panel socket, or connect it with the alligator clip test leads provided. No preliminary set-up is needed. The unit safely and automatically identifies low, medium and high-power PNP and NPN transistors. The ASI Transistor Checker also permits matching similar transistors in actual operating circuits, and provides a reliable GO/NO-GO test at practical collector currents (from 5mA on small signal types to 50mA and more on power types.) Match similar type transistors by observing and comparing dial readings; the higher the reading, the higher the gain. Completely assembled — battery operated. ("C" cell battery not included.)



CLOSE-OUT

Trans-Check $9.95

EPROM Erasing Lamp



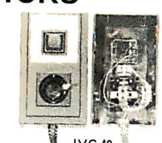
- Erases 2708, 2716, 1702A, 5203Q, 5204Q, etc.
- Erases up to 4 chips within 20 minutes.
- Maintains constant exposure distance of one inch.
- Special conductive foam liner eliminates static build-up.
- Built-in safety lock to prevent UV exposure.
- Compact — only 7-5/8" x 2-7/8" x 2"
- Complete with holding tray for 4 chips.

UVS-11E $79.95

JOYSTICKS

JS-5K

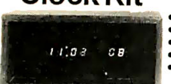




JVC-40

JS-5K	5K Linear Taper Pots	$5.25
JS-100K	100K Linear Taper Pots	$4.95
JVC-40	40K (2) Video Controller in case ...	$5.95

6-Digit Clock Kit



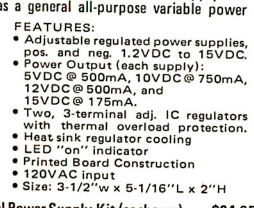


- Bright .300 ht. comm. cathode display
- Uses MM5314 clock chip
- Switches for hours, minutes and hold modes
- Hrs. easily viewable to 20 ft.
- Simulated walnut case
- 115 VAC operation
- 12 or 24 hr. operation
- Incl. all components, case & wall transformer
- Size: 6¾" x 3-1/8" x 1¾"

JE701 .... $19.95

NEW! JE215 Adjustable Dual Power Supply

General Description: The JE215 is a Dual Power Supply with independent adjustable positive and negative output voltages. A separate adjustment for each of the supplies provides the user unlimited applications for IC current voltage requirements. The supply can also be used as a general all-purpose variable power supply.



FEATURES:
- Adjustable regulated power supplies, pos. and neg. 1.2VDC to 15VDC.
- Power Output (each supply): 5VDC @ 500mA, 10VDC @ 750mA, 12VDC @ 500mA, and 15VDC @ 175mA.
- Two, 3-terminal adj. IC regulators with thermal overload protection.
- Heat sink regulator cooling
- LED "on" indicator
- Printed Board Construction
- 120VAC input
- Size: 3-1/2"w x 5-1/16"L x 2"H

JE215 Adj. Dual Power Supply Kit (as shown) . . $24.95

(Picture not shown but similar in construction to above)

JE200 Reg. Power Supply Kit (5VDC, 1 amp) . .	$14.95
JE205 Adapter Brd. (to JE200) ±5,±9 & ±12V.	$12.95
JE210 Var. Pwr. Sply. Kit, 5-15VDC, to 1.5amp.	$19.95

MICROPROCESSOR COMPONENTS

8080A/8080A SUPPORT DEVICES		
INS8080A	CPU	4.95
DP8212	8-Bit Input/Output	3.25
DP8214	Priority Interrupt Control	5.95
DP8216	Bi-Directional Bus Driver	3.49
DP8224	Clock Generator/Driver	3.95
DP8226	Bus Driver	3.49
DP8228	System Controller/Bus Driver	4.95
DP8238	System Controller	5.95
INS8243	I/O Expander for 48 Series	9.95
INS8250	Asynchronous Comm. Element	16.95
DP8251	Prog. Comm. I/O (USART)	7.95
DP8253	Prog. Interval Timer	14.95
DP8255	Prog. Peripheral I/O (PPI)	9.95
DP8257	Prog. DMA Control	19.95
DP8259	Prog. Interrupt Control	14.95
DP8275	Prog. CRT Controller	49.95
DP8279	Prog. Keyboard/Display Interface	19.95
DP8300	Octal Bus Receiver	6.95
DP8303	System Timing Element	6.95
DP8304	8-Bit Bi-Directional Receiver	3.95
DP8307	8-Bit Bi-Directional Receiver	3.95
DP8308	8-Bit Bi-Directional Receiver	3.95
6800/6800 SUPPORT DEVICES		
MC6800	MPU	14.95
MC6802CP	MPU with Clock and RAM	19.95
MC6810API	128x8 Static RAM	4.95
MC6821	Peripheral Inter. Adapt (MC6820)	7.49
MC6828	Priority Interrupt Controller	10.95
MC6830L8	1024x8-Bit ROM (MC68A30-8)	14.95
MC6850	Asynchronous Comm. Adapter	6.95
MC6852	Synchronous Serial Data Adapter	6.95
MC6860	0-600bps Digital MODEM	10.95
MC6862	2400bps Modulator	12.95
MC6880A	Quad 3-State Bus. Trans. (MC8T26)	2.25
MICROPROCESSOR CHIPS		
Z80 (780C)	CPU (MK3880N) (2MHz)	13.95
Z80A (780-1)	CPU (MK3880N-4) (4MHz)	15.95
CDP1802	CPU	19.95
2650	MPU	16.95
IDM2901ADC	CPU—4-Bit Slice (Com. Temp. Grade)	19.95
MCS6502	MPU w/Clock (65K Bytes Memory)	11.95
INS8035N-6	MPU—8-Bit (6MHz)	16.95
INS8039N-6	CPU—Sgl. Chip 8-Bit (128 bytes RAM)	19.95
INS8040N-6	CPU (256 Bytes RAM)	24.95
INS8070N	CPU—64 Bytes RAM	24.95
INS8073N	CPU w/Basic Micro Interpreter	29.95
P8085	CPU	19.95
INS8900	CPU—16-Bit	29.95
TMS9900JL	MPU—16-Bit	49.95
SHIFT REGISTERS		
MM500H	Dual 25-Bit Dynamic	.50
MM503H	Dual 50-Bit Dynamic	.50
MM506H	Dual 100-Bit Static	.50
MM510H	Dual 64-Bit Accumulator	.50
MM1402	256-Bit Dynamic	3.95
MM5013	1024-Bit Dynamic/Accumulator	1.95
MM5016H	500/512-Bit Dynamic	.89
MM5034N	Octal 80-Bit	9.95
MM5035N	Octal 80-Bit	9.95
2504V (1404A)	1024-Bit Dynamic	3.95
2518N	Hex 32-Bit Static	4.95
2522V	Dual 132-Bit Static	2.95
2524V	512-Bit Dynamic	.99
2525V	1024-Bit Dynamic	2.95
2527V	Dual 256-Bit Static	2.95
2528V	Dual 250-Bit Static	4.00
2529V	Dual 240-Bit Static	4.00
2532N	Quad 80-Bit Static	2.95
3341PC	Fifo (Dual 80)	6.95
DATA ACQUISITION		
AF100-1CN	Universal Active Filter 2.5%	5.95
AF121-1CJ	Touch Tone Low Pass Filter	19.95
AF122-1CJ	Touch Tone Low Pass Filter	19.95
LM308AH	Super Gain Op Amp	1.00
LM334Z	Constant Current Source	1.30
LM335Z	Temperature Transducer	1.40
LF356N	JFET Input Op Amp	1.10
LF398N	Sample & Hold Amplifiers	3.95
LM399H	Temp. Comp. Prec. Ref. (.5ppm/C°)	4.95
ADC0804LCN	8-Bit A/D Converter (1 LSB)	4.95
DAC0806LCN	8-Bit D/A Converter (0.78% Lin.)	2.25

DATA ACQUISITION (CONTINUED)		
ADC0809CCN	8-Bit A/D Converter (8-Ch. Multi.)	5.25
ADC0817CCN	8-Bit A/D Converter (16-Ch. Multi.)	10.95
DAC1000LCN	10-Bit D/A Conv. Micro. Comp. (0.05%)	13.95
DAC1008LCN	10-Bit D/A Conv. Micro. Comp. (0.20%)	8.95
DAC1020LCN	10-Bit D/A Converter (0.05% Lin.)	8.49
DAC1022LCN	10-Bit D/A Converter (0.20% Lin.)	5.95
DAC1222LCN	12-Bit D/A Converter (0.20% Lin.)	9.95
CD4051N	8-Channel Multiplexer	1.19
AY-5-1013	30K BAUD UART	5.95
RAM'S		
1101	256x1 Static	1.49
1103	1024x1 Dynamic	.99
2101 (8101)	256x4 Static	3.95
2102	1024x1 Static	1.75
21L02	1024x1 Static	1.95
2111 (8111)	256x4 Static	3.95
2112	256x4 Static MOS	4.95
2114	1024x4 Static 450ns	3.95
2114L	1024x4 Static 450ns Low Power	4.95
2114-3	1024x4 Static 300ns	4.95
2114L-3	1024x4 Static 300ns Low Power	5.95
2117	16,384x1 Dynamic 550ns (house marked)	4.95
4116 (UPD416)	16K Dynamic 250ns	3.95
4164	64K Dynamic 250ns	49.95
MM2147J	4096x1 Fast 70ns	19.95
5101	256x4 Static	7.95
MM5261	1024x1 Dynamic Fully Decoded	.99
MM5262	2Kx1 Dynamic	.25
MM5280/2107	4096x1 Dynamic	4.95
MM5290J-2(4116)	16K Dynamic 150ns	5.25
MM5298J-3A	8K Dyn. 200ns (lower ½ of MM5290J)	4.95
UPD414/MK4027	4K Dynamic 16-pin	4.95
TMS4044-45NL	4K Static	14.95
TMS4045	1024x4 Static	14.95
PROMS/EPROMS		
1702A	2K UV Erasable PROM	5.95
2708	8K EPROM	5.95
TMS2716	16K EPROM (-5V, +5V, +12V)	19.95
2716 Intel (2516) TI	16K EPROM (Single +5V)	10.95
2732 Intel (2532) TI	32K EPROM	19.95
2758	8K EPROM (450ns) (Single +5V)	7.95
5203	2048 PROM	14.95
82S23 (74S188)	32x8 PROM (Open Collector)	4.95
82S115	4096 Bipolar PROM	19.95
82S123 (74S288)	32x8 Tri-State Bipolar PROM	4.95
82S185	8K PROM	29.95
ROM'S		
2513 (2140)	Character Generator (Upper Case)	9.95
2513 (3021)	Character Generator (Lower Case)	9.95
2516N	Character Generator	10.95
MM5230N	2048-Bit Read Only Memory	1.95
NMOS READ ONLY MEMORIES		
MCM66710P	128x9x7 ASCII Shifted w/Greek	13.50
MCM66740P	128x9x7 Math Symbol & Pictures	13.50
MCM66750P	128x9x7 Alpha. Control Char. Gen.	13.50
MICROPROCESSOR MANUALS		
M-Z80	User Manual	7.50
M-CDP1802	User Manual	7.50
M-2650	User Manual	5.00
SPECIAL FUNCTION		
DS0025CN	Dual MOS Clock Driver (5MZ)	3.50
DS0026CN	Dual MOS Clock Driver (5MZ)	1.95
INS1771N-1	Floppy Disc Controller	24.95
INS2651N	Communication Chip	19.95
MM58167N	Microprocessor Real Time Clock	8.95
MM58174N	Microprocessor Compatible Clock	11.95
COP402N	Microcontroller with 64-Digit RAM and Direct LED Drive	6.95
COP402MN	Microcontroller with 64-Digit RAM & Direct LED Drive w/N Buss Int.	7.49
COP470N	32-Seg. VAC Fluor. Driver (20-pin pkg.)	3.25
TELEPHONE/KEYBOARD CHIPS		
AY-5-9100	Push Button Telephone Dialer	14.95
AY-5-9200	Repertory Dialer	14.95
AY-5-9500	CMOS Clock Generator	4.95
AY-5-2376	Keyboard Encoder (88 keys)	11.95
HD0165-5	Keyboard Encoder (16 keys)	7.95
74C922	Keyboard Encoder (16 keys)	5.49
74C923	Keyboard Encoder (20 keys)	5.75
MM53190N	Push Button Pulse Dialer	7.95
MM57499N	96/144-Key Serial Keyboard Encoder	8.95

ELECTRONIC TOY MOTORS

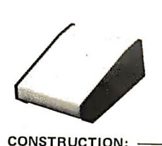
Typical Power Source	Operating Voltage Range	Voltage	No Load Speed RPM	No Load Current AMP	At Maximum Efficiency Speed RPM	At Maximum Efficiency Current AMP	At Maximum Efficiency Torque OZ. IN.	At Maximum Efficiency Output W	At Maximum Efficiency Eff. %	Small Torque OZ. IN.
DRY CELL	1.5-6.0	3.0	9,200	0.20	6,750	0.90	0.260	1.30	57.0	0.97

(Header group: TYPICAL CHARACTERISTICS)

.937 O.D. X 1.201 Length

MABUCHI RE280 $ .99 each . . . 10/$7.50 . . . 100/$50.00

DESIGNERS' SERIES
Blank Desk-Top Electronic Enclosures

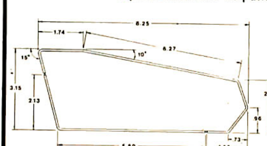






CONSTRUCTION:

The "DTE" Blank Desk Top Electronic Enclosures are designed to blend and complement today's modern computer equipment and can be used in both industrial and home. The end pieces are precision molded with an internal slot (all around) to accept both top and bottom panels. The panels are then fastened to ¼" thick tabs inside the end pieces to provide maximum rigidity to the enclosure. For ease of equipment servicing, the rear/bottom panel slides back on slotted tracks while the rest of the enclosure remains intact. Different panel widths may be used while maintaining a common profile outline. The molded end pieces can also be painted to match any panel color scheme.



Enclosure Model No.	Panel Width	PRICE
DTE-8	8.00"	$29.95
DTE-11	10.65"	$32.95
DTE-14	14.00"	$34.95

$10.00 Min. Order — U.S. Funds Only
Calif. Residents Add 6% Sales Tax
Postage — Add 5% plus $1 Insurance

Spec Sheets — 25¢
Send 52¢ Postage for your
FREE 1981 JAMECO CATALOG

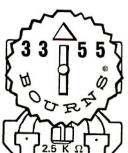


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(415) 592-8097

MAIL ORDER ELECTRONICS — WORLDWIDE
1355 SHOREWAY ROAD, BELMONT, CA 94002
PRICES SUBJECT TO CHANGE

6/81

Bourns Potentiometer



3/4 Watt Single Turn
(TOP ADJUSTMENT)

Values: 500Ω 1K 2.5K 5K 10K 25K 50K 100K 250K 500K 5Meg

INDIVIDUAL PRICING:

1-49	50-99	100-999	1K-up
.19	.17	.15	.12

GB174 ...... $1.95/lot
(25 pieces all 11 asst. values)

To order: Specify Bourns 3355 — (Value desired)

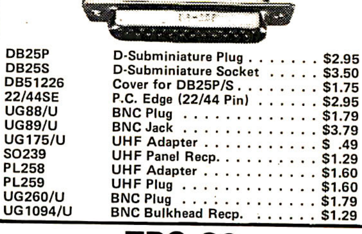
AC and DC Wall Transformers



Ideal for use with clocks, games, power supplies or any other type of AC or DC application.

Part No.	Input	Output	Price
AC 250	117V/60Hz	12 VAC 250mA	$3.95
AC 500	117V/60Hz	12 VAC 500mA	$4.95
AC1000	117V/60Hz	12 VAC 1 amp	$5.95
AC1700	117V/60Hz	9 VAC 1.7 amp	$6.95
DV 9200	117V/60Hz	9 VDC 200mA	$3.25
DC 900	120V/60Hz	9 VDC 500mA	$3.95

CONNECTORS



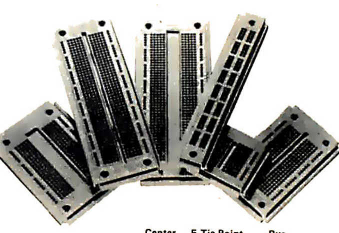
DB25P	D-Subminiature Plug	$2.95
DB25S	D-Subminiature Socket	$3.50
DB51226	Cover for DB25P/S	$1.75
22/44SE	P.C. Edge (22/44 Pin)	$2.95
UG88/U	BNC Plug	$1.79
UG89/U	BNC Jack	$3.79
UG175/U	UHF Adapter	$ .49
SO239	UHF Panel Recp.	$1.29
PL258	UHF Adapter	$1.60
PL259	UHF Plug	$1.60
UG260/U	BNC Plug	$1.79
UG1094/U	BNC Bulkhead Recp.	$1.29

TRS-80 16K Conversion Kit

Expand your 4K TRS-80 System to 16K.
Kit comes complete with:
★ 8 ea. MM5290 (UPD416/4116) 16K Dyn. Rams (*NS)
★ Documentation for Conversion

TRS-16K2	*150NS	$39.95
TRS-16K4	*250NS	$29.95

GLOBAL SPECIALTIES
EXPERIMENTOR SOCKETS



Model	Length	Width	Center Channel	5 Tie Point Terminals	Bus Strips	Price
EXP4B	6.0"	1.0"	n/a	n/a	4(160)	$ 4.75
EXP300	6.0"	2.1"	.3"	94(470)	2(80)	$12.00
EXP325	1.8"	2.1"	.3"	22(110)	2(20)	$ 3.50
EXP350	3.6"	2.1"	.3"	46(230)	2(40)	$ 6.75
EXP600	6.0"	2.4"	.6"	94(470)	2(80)	$14.75
EXP650	3.6"	2.4"	.6"	46(230)	2(40)	$ 8.75

Quick Test Sockets & Bus Strips

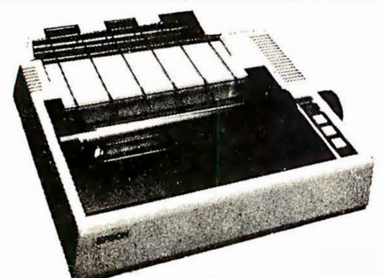


	Length	Hole to-hole	Terminals	Unit Price $
QT-59S	6.5"	6.2"	118	$12.25
QT-59B	6.5"	6.2"	20	$ 2.75
QT-47S	5.3"	5.0"	94	$ 9.75
QT-47B	5.3"	5.0"	16	$ 2.50
QT-35S	4.1"	3.8"	70	$ 7.25
QT-35B	4.1"	3.8"	12	$ 2.20
QT-18S	2.4"	2.1"	36	$ 4.50
QT-12S	1.8"	1.5"	24	$ 3.75
QT-8S	1.4"	1.1"	16	$ 3.00
QT-7S	1.3"	1.0"	14	$ 2.75

Circle 185 on inquiry card.

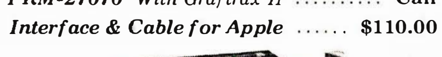
Low Prices,

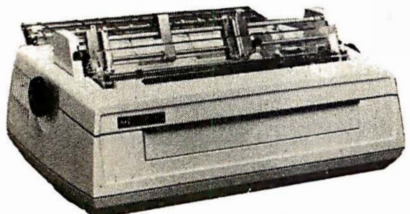
Printers



MX-80 - Epson
132 column, 9 x 9 dot matrix, multiple fonts
PRM-27080 *Save $100.00* .... **Call**

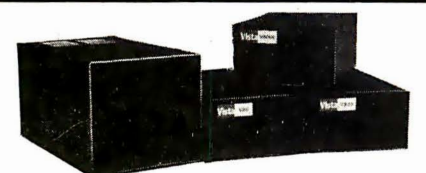
MX-70
PRM-27070 With Graftrax II .... **Call**
Interface & Cable for Apple **$110.00**





SPINWRITER - NEC
65 cps, bi-directional, letter quality printer with deluxe tractor mechanism, both parallel and serial interfaces on-board, 16K buffer, ribbon, print thimble, graphics, micro-space justification, data cable, and self test/diagnostic ROM.
PRD-55511 *without 16K buffer* ... **$2795.00**
PRD-55512 *with 16K buffer* **$2895.00**

Accessories for TRS-80



DISK DRIVES for TRS-80
23% more storage, 8 times faster, 40 track with free patch, 120 day warranty.
MSM-12410C *Save $125.00 !!!* **$325.00**

8" DISK DRIVES for MODEL II
2 double density drives with cabinet, power supply, & cables
END-000433 *Kit* **$1050.00**
END-000434 *Assembled* **$1250.00**
WCA-5036A *Cable (required)* **$29.95**

Special Purchase - Save $50.00
Novation Cat Modem
300 baud, answer and originate



IOM-5200A *List price $189.95* **$139.95**
D-CAT 300 baud, direct connect modem
IOM-5201A *Special sale price* **$189.00**
AUTO-CAT Auto answer/origiate, direct connect
IOM-5230A *Special sale price* **$239.95**

Accessories for Apple



16K MEMORY UPGRADE
Add 16K of RAM to your TRS-80, Apple, or Exidy in just minutes. We've sold thousands of these 16K RAM upgrades which include the appropriate memory chips (as specified by the manufacturer), all necessary jumper blocks, fool-proof instructions, and our 1 year guarantee.
MEX-16100K *TRS-80 kit* **$29.00**
MEX-16101K *Apple kit* **$29.00**
MEX-16102K *Exidy kit* **$29.00**

16K RAM Card - Microsoft
(There is life after 48K)
MEX-16300A *A & T* **$174.95**

Z-80* CARD for APPLE
Two computers in one, Z-80 & 6502, more than doubles the power & potential of your Apple, includes Z-80 CPU card, CP/M 2.2, & BASIC-80*
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Atari 800 $799.95

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Joy stick with pots for Apple II
SYA-1510A *A & T* **$49.95**

VISICALC - Personal Sftwr
The ultimate program for your Apple II
SFA-24101005M *Complete package* **$139.95**

DOS 3.3 UPGRADE - Apple
Upgrade your old DOS to the improved 3.3
IOD-2233A *Complete kit* **$64.95**

DISK DRIVE for APPLE
5¼" disk drive with controller for your Apple
MSM-12310C *with controller* **$475.00**
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8" DRIVES for APPLE
Controller, DOS, two 8" double densisty drives, cabinet, power supply, & cables
Special Package Price *Kit* **$1399.95**

PRINTER INTERFACE - C.C.S.
Centronics type I/O card w/ firmware
IOI-2041A *A & T* **$99.95**

AIO, ASIO, APIO - S.S.M.
Parallel & serial interface for your Apple (see Byte pg 11)
IOI-2050K *Par & Ser kit* **$129.95**
IOI-2050A *Par & Ser A & T* **$159.95**
IOI-2052K *Serial kit* **$89.95**
IOI-2052A *Serial A & T* **$99.95**
IOI-2054K *Parallel kit* **$69.95**
IOI-2054A *Parallel A & T* **$89.95**

A488 - S.S.M.
IEEE 488 controller, uses simple basic commands, includes firmware and cable, 1 year guarantee, (see April Byte pg 11)
IOX-7488A *A & T* **$399.95**

Disk Drives

*JADE's new dual disk sub-assemblies include: **Handsome** metal cabinet with **proportionally balanced** air flow system, **assembled & tested** dual drive power supply, **quiet whisper type** cooling fan, power-cable kit, lighted power switch, approved fuse assembly, line cord, **Never-Mar** rubber feet, and all necessary hardware to mount 2-8" disk drives - it's **all American made, guaranteed for six months**, and it's in stock!*

Dual 8" Sub-Assembly Cabinet
END-000421 *Cabinet kit* **$225.00**
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END-000424 *A & T w/2 8" drives* **$1195.00**

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END-000426 *kit w/2 8" drives* **$1495.00**
END-000427 *A & T w/2 8" drives* **$1695.00**

8" DISK DRIVES
Highly reliable double density floppy disk drives
Shugart 801R single sided, double density
MSF-10801R *SA-801R* **$425.00**
Special Sale Price .... ***2 for $790.00***

Shugart 851R double sided, double density
MSF-10851R *SA-851R* **$595.00**
Special Sale Price .... ***2 for $1150.00***

Siemens FDD100-8D2 single sided, double density
MSF-201120 *6 mo warranty* **$385.00**
Special sale price .... ***2 for $750.00***

Qume Datatrak 8 double sided, double density
MSF-750080 *SA-851R compatible* .. **$599.95**
Special sale price .... ***2 for $1160.00***

JADE DISK PACKAGE
Double density controller, two 8" double density floppy disk drives, CP/M 2.2 (configured for controller), hardware and software manuals, boot PROM, cabinet, power supply, fan, & cables
Special Package Price *Kit* **$1395.00**

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DISKETTES - Jade
Bargain prices on magnificent magnetic media
5¼" single sided, single density, box of 10
MMD-5110103 *Soft sector* **$27.95**
MMD-5111003 *10 sector* **$27.95**
MMD-5111603 *16 sector* **$27.95**
5¼" double sided, double density, box of 10
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8" single sided, single density, box of 10
MMD-8110103 *Soft sector* **$33.95**
8" single sided, double density, box of 10
MMD-8120103 *Soft sector* **$39.95**
8" double sided, double density, box of 10
MMD-8220103 *Soft sector* **$49.95**

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13" COLOR MONITOR - Zenith
The hi res color you've been promising yourself
VDC-201301 .... **$449.00**

12" GREEN SCREEN - NEC
20 MHz, P31 phosphor video monitor with audio, exceptionally high resolution - A fantastic monitor at a very reasonable price
VDM-651200 *12" monitor* **$259.95**

Leedex / Amdek
Reasonably priced video monitors
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THE STAR MODEM from LIVERMORE

FEATURE FITS GTE HANDSETS!

2 YEAR WARRANTY

EXCLUSIVE ACOUSTIC CHAMBERS

The exclusive triple seal of Livermore's new flat mounted cups locks the handset into the acoustic chamber yielding superior acoustic isolation and mechanical cushioning. Designed to adapt to most common handsets used throughout the world, the STAR offers the utmost in flexibility and transmission reliability.

Specifications:
- **Data Rate:** 0 to 300 baud
- **Compatibility:** Bell 103 and 113; CCITT
- **Frequency Stability:** ±0.3 percent. Crystal controlled
- **Receiver Sensitivity:** −50 dBm ON, −53 dBm OFF
- **Modulation:** Frequency shift keyed (FSK)
- **Carrier Detect Delay:** 1.2 seconds ON; 120 msec OFF
- **EIA Terminal Interface:** Compatible with RS 232 specifications
- **Teletype Interface:** 20 milliampere current loop
- **Optional Interfaces:** IEEE 488; TTL; TTY 43
- **International (CCITT) frequencies available**
- **Switches:** Originate/Off/Answer; Full Duplex/Test/Half Duplex
- **Indicators:** Transmit Data, Receive Data, Carrier Ready, Test
- **Power:** Supplied by 24 VAC/150 MA UL/CSA listed wall-mount transformer. Input 115 VAC, 2.5 watts. (A 220 VAC, 50 Hz adaptor is available upon request.)
- **Dimensions:** 10" x 4" x 2"
- **Weight:** 1.74 lbs. (3 lbs. shipping weight including AC adaptor.)
- **Warranty:** Two years on parts and labor, excluding the AC adaptor which carries the manufacturer's warranty

Part No.	Description	List Price	SALE PRICE
LIV-STAR	RS232, TTL, 20 MA Current Loop	$199.00	$129.00
LIV-STAR-V21	CCITT European Standard	$229.00	$209.00
LIV-IEEE	IEEE 488 Standard	$395.00	$279.00
LIV-IEEE-V21	IEEE 488, CCITT Standard	$465.00	$369.00

CABLES

Part No.	Description	Price
CND-RS2328F	RS232 8 Cond 8 ft.	$19.95
LIV-I2I	IEEE to IEEE 2 Meter	$59.95
LIV-I2PET	IEEE to Pet 2 Meter	$59.95

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SOLDER TAIL PRICE

Part No.	1-9	10-24	25-99	100-249
S100 STG	3.20	2.90	2.50	2.20

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S100 WWG	4.00	3.75	3.50	3.25

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2708 450ns 8K EPROM — $8.50 EA. 8/$32.00

2716 450ns 5 Volt only 16 K EPROM — $11.95 EA 8/$48.00

2114-3L 4096 BIT (1024x4) 300ns LOW POWER STATIC RAM 8/$30.00 100 + $3.00

5257-3L (TMS 4044) 4096x1 300ns LOW POWER STATIC RAM 8/$50.00 100 pcs. + $4.75

TRS-80/APPLE MEMORY EXPANSION KITS

4116's RAMS *from Leading Manufacturers* (16Kx1 200ns)

100% GUARANTEED — 8 for $28.00 — 1,000's SETS SOLD

ADD $3.00 FOR PROGRAMMING JUMPERS FOR TRS-80 KEYBOARD

4116's 100 pcs & UP $3.00 each
1000 pcs & UP $2.75 each

Shugart SA801R SALE



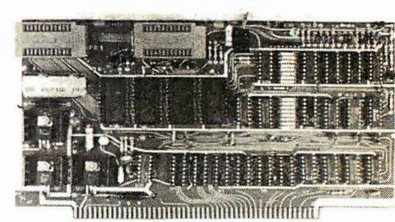
SHU-SA801R $425.00
2 OR MORE $395.00 ea.



CCS2422A FLOPPY DISK CONTROLLER WITH CP/M VERSION 2.2 — LIST $400.00 — SALE $375.00

IEEE S-100 COMPATIBLE SINGLE/DOUBLE DENSITY 5¼"/8" DISK DRIVES SINGLE//DOUBLE HEADED ASSEMBLED & TESTED

SSM



PB1 2708/2716 PROGRAMMER & 4K/8K EPROM BOARD

PB1 has two separate programming circuits so 2708 or 2716 (5v) type of EPROMs can be programmed without modifying the board. Programming voltage is generated on-board; no need for an external power supply. Programming sockets are Dip Switch addressable to any 4K boundary. And complete software is provided for programming and verifying EPROMs.

Unused EPROM sockets don't take memory space, so you are never committed to the full 4K or 8K of memory.

SPECIFICATIONS

Memory capacity .... 4096/8192 bytes (four sockets)
Memory type .... 2708 EPROM (not included) 2716 EPROM + 5V type (not included)
Addressing:
EPROM .... Any 4K boundary
programmer ..... Dip switch selection Separate 2708 and 2716 sockets
On-board .... Any 4K/8K boundary above 8000 Hex
EPROMs .... Dip switch selection Unused sockets do not enable data bus drive
Wait states .... 0 to 4 clock cycles
Buffering .... All lines buffered
Special feature ...... LED indicator for programming mode Switch to turn-off programming voltage prevents accidental ROM programming Textool sockets (for programming only)

		List Price	Our Price
SSMPB1K	Kit		$179.00
SSMPB1A	Assembled & Tested	$265.00	$230.00

MB8A 1K/16K EPROM BOARD

The MB8A provides sockets to support up to 16 2708 EPROMs—the most widely used EPROM in the microcomputer industry. The board disables in 1K increments simply by removing the 1K EPROMs. For example, with 8 EPROMs, it acts as an 8K board.

The MB8a's Magic Mapping enables the user to overlay RAM and ROM at the same address in any desired increment when used with RAM boards equipped with Phantom Disable.

		List Price	Our Price
SSMMB8AK	Kit		$114.00
SSMMB8AA	Assembled & Tested	$179.00	$159.00

ECONOROM 2708 16K x 8 EPROM BOARD USING 2708

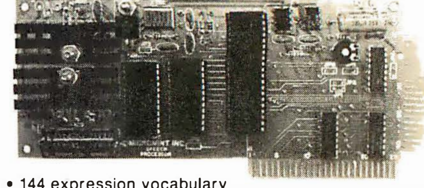
The ECONOROM 2708 EPROM board is the ideal memory board for the user who wishes to place his software in reliable, low cost, and non-volatile 2708 EPROMs. With its on-board Power-On-Jump circuitry, the ECONOROM 2708 board is the ideal addition to any IEEE 696/S-100 system.

		List Price	Our Price
GBT125U	Unkit		$ 85.00
GBT125A	Assembled & Tested	$135.00	$120.00
GBT125C	CSC	$195.00	$175.00

Ciarcia's Circuit Cellar

MICROMOUTH SPEECH PROCESSOR

AS FEATURED IN JUNE BYTE, PAGE 46



- 144 expression vocabulary
- Assembled and Tested
- Complete Documentation
- Connect to a speaker or Power Amplifer
- Plugs into Apple II
- Plug compatable with TRS-80 Model 1
- May be adapted to run on the S-100, H-8, or any parallel part.

		OUR PRICE
MMI-94V0 APL	for use with APPLE II, or modified to run with other parallel parts	$149.00
MMI-94V0 TRS1	TRS-80 Model compatible complete with interface cable and AC Adapter, less enclosure.	$169.00

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Sales Prices are for prepaid orders only. Credit Card orders will be charged appropriate freight.

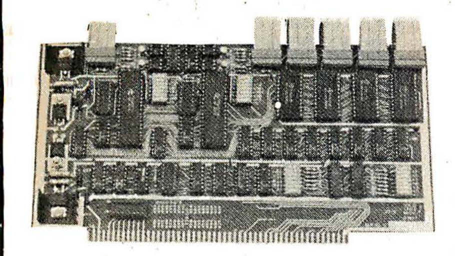
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SSM



I/04 2 Parallel & 2 Serial I/O Board

Number of parts - Two serial ports with status • Two parallel inputs • Two parallel outputs • **Serial Interface** -Current-loop by optical isolators • 20/60 ma current-loop • EIA receivers and drivers • 55 to 9600 baud • 134.5 baud (optional) for running selectrics • UART presets by dip switch: —stop bits, —word length, —parity even and odd • + 5V, 12V & – 12V available at connector • **Parallel Interface** - Latch type—8212 • + 5V & – 12V available at connector • **Addressing** - Dip switch addressing of serial I/O to any four port boundary • Dip switch addressing of parallel I/O to any two port boundary • **Prototyping area** - 2 x 16 pin spare patterns



	List Price	Our Price
SSMIO4K Kit		**$210.00**
SSMIO4A A&T	**$290.00**	**$260.00**

INTERFACE I 2 Serial

Our I/O board gives you inparalleled flexibility and operating convenience. We include such features as:

- 2 independently addressable serial ports (dip switch selectable addresses)
- Real LSI Hardware UARTs for minimum CPU housekeeping.
- RS232C, current loop (20mA), & TTL signals on both ports.
- Precision, crystal-controlled Baud rates up to 19.1 KBaud (Individually dip switch selectable)
- Transmit & receive interrupts on both channels, jumperable to any vectored interrupt line.
- Industry standard RS232 level converters with five RS232 handshaking lines per port.
- Optically isolated current loop with provisions for both on-board & off-board current sources.
- UART parameters, interrupt enables, & RS 232 handshaking lines are software programmable with power-on hardware detault to customer specified hard-wired settings for maximum flexibility.

		List Price	OUR PRICE
GBT133U	UNKIT		$199.00
GBT133A	A&T	$249.00	$219.00

INTERFACER II 3P/1S

- 1 independently addressable serial port
- RS232C; 20mA current loop, & TTL signals
- Precision crystal controlled Baud rate generator
- Up to 19.2K Baud
- Transmit and receive interrupts, jumperable to and vectored interrupt line
- Five RS232 handshaking lines
- Optically isolated current loop
- 3 parallel I/O
- Utilizes LSTTL octal latches for latched I/O data with 24mA drive current
- Enable & strobe bits on each port (each with selectable polarity)
- Interrupts for each input port
- Separate 25 pin connector with power for each channel and a status port for interrupt mask & port status

		List Price	OUR PRICE
GBT150U	UNKIT		$199.00
GBT150A	A&T	$249.00	$219.00

TOLL FREE!!!

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CompuPro™ from GODBOUT

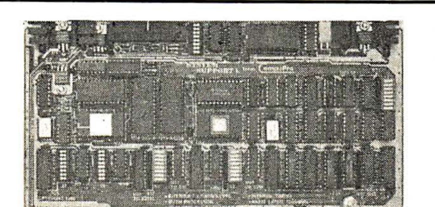
SPECTRUM
S-100 COLOR GRAPHICS BOARD

The **SPECTRUM COLOR GRAPHICS** Board is actually three products in one: a full-function color graphics generator; a parallel I/O port; and an 8K static RAM board. These three sections work together to create a new standard of flexibility in the generation of color graphics.

ALPHANUMERIC AND GRAPHICS MODES AVAILABLE

MODE	DENSITY	AVAILABLE COLORS	RAM USED
ALPHA	32 X 16	2	512 BYTES
SEMIGRAPH	64 X 32	8	512 BYTES
GRAPHICS	64 X 64	4	1K BYTES
GRAPHICS	128 X 64	2	1K BYTES
GRAPHICS	128 X 64	4	2K BYTES
GRAPHICS	128 X 96	2	1.5K BYTES
GRAPHICS	128 X 96	4	3K BYTES
GRAPHICS	128 X 192	2	3K BYTES
GRAPHICS	128 X 192	4	6K BYTES
GRAPHICS	256 X 192	2	6K BYTES

		LIST PRICE	OUR PRICE
GBT144U	UNKIT		$299.00
GBT144A	A&T	$399.00	$349.00
GBT144C	CSC	$449.00	$399.00
GBT20	SUBLOGIC UNIVERSAL GRAPHICS INTERPRETER SOFTWARE		$35.00



SYSTEM SUPPORT 1
MULTIFUNCTION BOARD

This multi-purpose S-100 board provides your computer with the most needed system support functions at less cost than buying numerous single function boards. Includes sockets for 4K of extended address EPROM or RAM (2716 pinout), 1 socket with battery backup; crystal controlled month/day/year/time clock with BCD outputs; optional high speed math processor (9511 or 9512); full RS-232 serial port; three 16 bit interval timers (cascade or use independently); two interrupt controllers service 15 levels of interrupts; power fail indicator with provision to switch CMOS memory to battery backup; and comprehensive owner's manual with numerous software examples. Conforms fully to all IEEE 696/S-100 standards.

Want to make your S-100 system more versatile? System Support 1 is the answer.

- 4K of EPROM or RAM (2716 type).
- 15 levels of vectored interrupts.
- 3 independent 16 bit interval timers.
- Real time clock/calendar with battery backup capability.
- Full RS-232C serial port with software selectable baud rate.
- Optional high speed math processor (9511 or 9512, your choice).
- 1, 2, 4 or 8 wait states selectable to accomodate the fastest CPUs.
- ROM/RAM can be enabled or disabled by PHANTOM.
- ROM/RAM can respond to full IEEE extended address (24 bits).

		List Price	Our Price
GBT 162U	unKit		$295.00
GBT 162A	A&T	$395.00	$360.00
GBT 9512	Math Chip		$195.00

SSM

VB3 80 Character Video Board

VB3 is the perfect video interface for word processing and other applications requiring 80 characters per line. It produces a standard 80 x 24 display or as much as 80 x 48 for a full page of text. VB3 can display upper and lower case characters, up to 256 user defined symbols, and a 160 x 192 matrix for graphics.

VB3 is memory mapped, but occupies memory only when activated. So one or more VB3s can be located at the same address with a full 65K of memory still available to the user.

It generates both US and European T.V. rates and includes a keyboard input. Software includes a CP/M compatible driver routine.

SPECIFICATIONS:
Display - 80 char. per line, up to 48 lines • Graphics up to 160 x 192 matrix • Upper & lower case characters • Up to 256 user defined symbols (optional EPROM) • Software controlled options: Inverted video, graphic char. (2x4), 1 level of gray, blinking char., underline, strike thru, blank-out char., cursor.
Timing - Software controlled timing, top & bottom margins, horiz. position • U.S. & European T.V. timing • Full interlace or non-interlace • Crystal—16 MHz (dot rate)
Interface - Composite video, =75 OHM • Verti./horiz. drive output & sync input • Memory mapped
Keyboard - Keyboard port with status • Dip switch addressing of ports
On-board RAM - 4096 Bytes (8192 bytes optional) • 2114L (250 nsec or 450 nsec) • Switch addressing, 8K increments • On-board bank-select of RAM
Buffering - All lines buffered
Software - CP/M compatible driver routine • Powerful terminal simulator routine

		List Price	SALE PRICE
SSM-VB3K24	80x24 KIT	$425.00	$359.00
SSM-VB3A24	80x24 A&T	$499.00	$450.00
SSM-VB3K48	80x48 KIT	$475.00	$425.00
SSM-VB3A4B	80x48 A&T	$549.00	$495.00
SSM-VB3UP	24x48 Line Upgrade Kit		$50.00

Video Interface Software
CP/M Compatible 8" Disk, containing
- CP/M BIOS Driver
- Super Intelligent Terminal Routines
- Graphics Routine
- Menu-Driven Initialization Routine
- Misc. User - Contributed Programs

		Our Price
SSM-VB3SOFT	Video Interface Software	$50.00

VB1C Memory Mapped Video Board

One of the most popular S-100 video boards available, this VBIB is software controlled and memory mapped. Memory Mapping means that locations in the 1K (1024 byte) on-board RAM memory correspond with locations in the 64 x 16 (1024) character display.

The 1K memory can be addressed at any 1K increment via DIP switch.

The VBIB features a 128 x 48 matrix for graphics upper and lower case, Greek letters, and black on white or white on black. Software includes a driver routine for cursor control, scroll-up, and X-Y graphic control.



		List Price	SALE PRICE
SSM-VB1CK	KIT	$179.00	$159.00
SSM-VB1CA	A&T	$242.00	$205.00

VB2 I/O Mapped Video Board

The VB2, is an I/O controlled video interface board. With a TV monitor, the VB2 becomes a video terminal. No other I/O card is required for keyboard input and video display.

The VB2 cursor, linefeed, carriage return, backspace, and clear-screen are hardware controlled. The display is 64 x 16, all upper case, and is selectable for white on black, or black on white. The board produces a clear, bright display, and features adjustable picture size and character width. Circuitry is provided to drive a speaker for a tone.

		List Price	SALE PRICE
SSM-VB2K	KIT	$199.00	$169.00
SSM-VB2A	A&T	$269.00	$229.00

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OUR LOWEST PRICES OF THE YEAR!



Single and dual trace, 15 thru 100 MHz. All high sensitivity Hitachi oscilloscopes are built to demanding Hitachi quality standards and are backed by a 2-year warranty. They're able to measure signals as low as 1mV/division (with X5 vertical magnifier). It's a specification you won't find on any other 15 or 30 MHz scopes. Plus: Z-axis modulation, trace rotation, front panel X-Y operation for all scope models, and X10 sweep magnification. And, 30 thru 100 MHz oscilloscopes offer internal signal delay lines. For ease of operation, functionally-related controls are grouped into three blocks on the color coded front panel. Now here's the clincher: For what you'd expect to pay more, you actually pay less. Check our scopes before you decide. All scopes complete with probes.

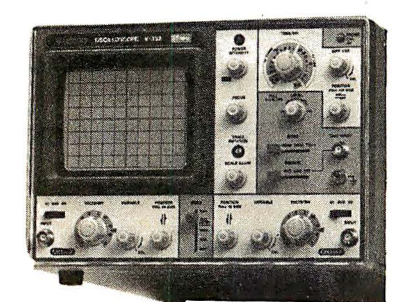
Hitachi...The measure of quality.

HITV302B

30MHZ DUAL TRACE OSCILLOSCOPE

List $995.00

SALE $819.00



- TV sync-separater circuit
- High-sensitivity 1mV/div (5MHz)
- Sweep-time magnifier (10 times)
- Z-axis input (intensity modulation)
- Signal delay line
- Complete with 2 probes
- CHI, CH2, DUAL, ADD, DIFF, Vertical Deflection Modes
- X-Y operation
- Trace Rotation

HITV152B DUAL TRACE 15MHZ (no delay)

LIST $735.00 **SALE $629.00**

HIT-V202

20MHz DUAL TRACE

LIST PRICE: $850

SALE PRICE: $775.00

- Dynamic range 8 div.
- TV sync-separator circuit
- Built-in signal delay line (V-352)
- X-Y operation
- Sweep-time magnifier (10 times)
- Trace rotation system
- Fine-adjusting, click-positioning function

HIT-V352

35MHz DUAL TRACE WITH DELAY

LIST PRICE: $1150.00

SALE PRICE $950.00

- Economically priced dual trace oscilloscope
- Square CRT with internal graticule (illuminated scale)
- High-accuracy voltage axis & time axis set at ± 3% (certified at 10° to 35°C)
- High-sensitivity 1mV/div.
- Low drift
- 2 Year Warranty

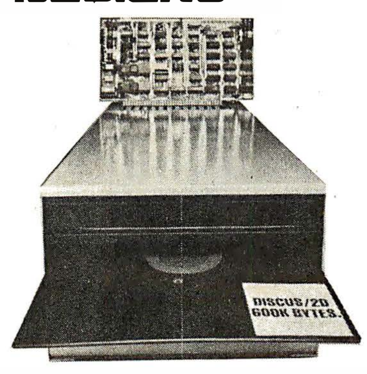
50MHz & 100 MHz DUAL TRACE WITH CALIBRATED TIME DELAY

HIT V550B 50MHz with 3rd TRACE TRIGGER VIEW LIST $1745.00 SALE **$1495.00**

HIT V1050 100MHz with 3rd & 4th TRACE TRIGGER VIEW LIST $2390.00 SALE **$1995.00**

The HITACHI V550B (50mHz) and V1050 (100mHz) offer all the capabilities you might expect from a lab grade oscilloscope. Capabilities such as 3rd trace trigger view, a bright 6" square CRT, and a max. sweep rate of 2ns/div (V1050) 5ns/div (V550B). Also, features you may not expect like, sensitivity of 1mv/div (V550B) .5mv/div (V1050) @ 10mHz, automatic focus correction.

MORROW DESIGNS



DISCUS/2D™ DOUBLE DENSITY DISK SYSTEM

COMPLETE WITH CP/M V2.2 AND MICROSOFT BASIC V5.2

Why not go all the way to the professional/industrial standard of 600K byte/side disk memory with your S-100 system? The new DISCUS/2D™ full-size, double-density floppy disk system is actually less expensive than many mini-floppy systems.

And Morrow Designs TM hasn't just made full-size, double-density disk memory affordable...we've made it more functional.

The data format is soft-sectored and compatible with IBM's new System 34. And DISCUS/2D™ accepts both single-density and double-density disks for complete flexibility in data storage.

And DISCUS/2D™ is even more attractive because it's priced and delivered as a truly complete system. It's complete with all hardware. It's complete with all necessary software. And it's completely assembled, tested and warranted.

Specifications:

- CP/M V2.2 and Microsoft Basic V5.2 Standard
- Plug compatible with Shugart, Remex and Siemens single- or double-sided drives
- Double/single-density capability utilizing MFM and FM data formats
- Western Digital 1791 LSI floppy disk controller chip
- Uses 2K of S-100 address space:
  - —1K PROM with built-in disk drive and I/O utility subroutines incorporating memory mapped I/O
  - —1K 2114-3L 300 ns access time RAM for disk data offering and general purpose use
- Starting address of memory space is 340:000 (E000 hex) for compatibility with other popular ROM based systems
- Phase-locked data separator and crystal controlled disk data write precompensation capability to insure the highest standards of data integrity in double density mode.
- Compatible with all 2, 4 and 5 MHz systems which conform with the proposed IEEE standard for the S-100 bus
- 1602 UART with crystal-controlled baud-rate generator
- Sixteen switch selectable baud rates from 50 to 19,200 bits/second
- TTY current loop and industry standard RS232C serial interface
- Power-on jump circuitry for automatic bootstrap loading from the disk drive
- Power supply requirements: + 8V @ 1200 ma; + 16V @ 150 ma; −16V @ 70 ma.
- ROM utility subroutines:

Bootstrap load	Seek
Terminal input	Set sector
Terminal output	Set DMA address
Horne	Disk read
Disk write	DMA status
Select drive	Disk status
Terminal panic detect	Disk error
Terminal status	Switch density

SINGLE SIDED

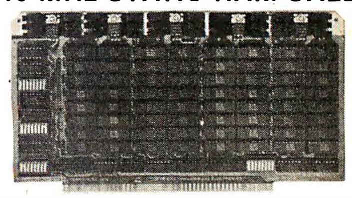
		List Price	SALE PRICE
MDSF-1218	Single Drive	$1199.00	$950.00
MDSF-1228	Double Drive	$1994.00	$1598.00

DOUBLE SIDED

		List Price	SALE PRICE
MDSF2218	Single Drive	$1545.00	$1198.00
MDSF2228	Double Drive	$2740.00	$2190.00



10 MHz STATIC RAM SALE

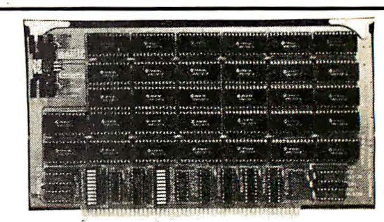


32K ECONORAM XX

32K Bank Select. IEEE S-100 compatible. Features one 32K block that can be addressed on 4K boundaries. Compatible with the IEEE proposed standard of 24 address lines as well as all currently used bank select configurations. Any or all of the eight 4K byte blocks may be disabled to create as many windows in memory to avoid any system memory conflicts.

10 MHz OPERATION

		List Price	SALE PRICE
GBT164A16	16K RAM A&T	$399.00	$319.00
GBT164A24	24K RAM A &T	$539.00	$449.00
GBT164A32	32K RAM A&T	$699.00	$499.00



ECONORAM 17 64K STATIC S-100 MEMORY

For critical high density applications where dynamic memory poses possible problems with DMA or speed, the Godbout RAM 17 64K STATIC RAM board represents the long awaited solution. Conforming fully to the IEEE 696/S-100 bus standard, RAM 17 provides 24 address lines for 16 megabytes extended addressing capability, and runs on far less power than dynamic memory.

- Meets or exceeds all IEEE 696/S-100 specifications
- Fully static design uses less power than dynamics (2W)
- 24 bit extended addressing
- 2K Window at E000, E800, F000, or F800 HEX (Ideal for many floppy disk controller boot proms)
- THAT'S RIGHT 64K STATIC 2 WATTS
- On board RAM's may be replaced by 2716 EPROM's (pin for pin)
- CSC and Assembled/Tested boards are designed for CPU speeds up to 10 MHz
- Thorough bypassing of all supply lines
- INCREDIBLE LOW POWER OPERATION (2 WATTS)
- Does DMA
- THAT'S 2 WATTS OF STATIC 64K RAM

		List Price	Sale Price
GBT 175A48	48K A&T	$1048.50	$950.00
GBT 175A64	64K A&T	$1395.00	$995.00

GBT 161 8085 CPU BOARD

GBT 1612 8085/8088 CPU BOARD

- 8088 & 8085A CPU
- S-100 IEEE COMPATIBLE
- SWITCHABLE CPU'S
- 5 MHZ OR 2 MHZ SWITCHABLE
- POWER ON JUMP TO ANY 256 BYTE BOUNDARY
- POWER ON JUMP CAN BE DISABLED
- CPU CAN JUMP ON POWER ON ONLY OR POWER ON AND RESET
- 24 BIT EXTENDED ADDRESSING
- IMSAI FRONT PANEL COMPATIBLE
- AVAILABLE WITH 8085A ONLY

BOARD WITH 8085 ONLY

		List Price	Our Price
GBT161A	Assembled & Tested	$325.00	$305.00

BOARD WITH 8085 & 8088

		List Price	Our Price
GBT1612A	Assembled & Tested	$425.00	$399.00



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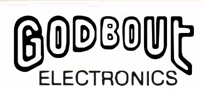
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division of



TEAMS UP WITH *PRIORITY ONE ELECTRONICS* TO INTRODUCE THE NEXT GENERATION OF IEEE/696 S-100 COMPUTERS

8 BIT

There are still a lot of 8 bit machines out in the world, matched with plenty of 8 bit software - but very few of these machines are working up to their peak capacity. We want the "Big 8" system to change all that, and bring professional level computing power to all the owners of older S-100 machines. And if you're assembling an 8 bit system from the ground up, "Big 8" gets you off to the best possible start ... regardless of price.

Here's what you get

1. CPU Z, our high speed, high performance Z80* based CPU board. Includes a 6 MHz CPU for maximum throughput and highest operating speed.
2. Disk 1 DMA floppy disk controller.
3. 64K of fast static RAM with 24 bit extended addressing.
4. Interfacer I - Dual Serial I/O card or Interfacer II 3 Parallel 1 Serial I/O Card.
5. CP/M*-80 2.2.
6. All documentation and manuals.

It all adds up to $2712.00

TOTAL PACKAGE PRICE

$1950.00

SAVE $762.00

ORDER PART NO. GBT-SPEC-C
Big 8 System with Interfacer I
ORDER PART NO. GBT SPEC-D
Big 8 System with Interfacer II

SAVE EVEN MORE, when you add 2 Shugart 801R disk drives, and a dual Cabinet with Power Supply.

This package adds up to $3962

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$3050.00

GBT-SPEC-E with Interfacer I
GBT-SPEC-F with Interfacer II

16 BIT

Step up to the world of 16 Bit computers now and save hundreds, even thousands of dollars if you act right now! We have made a one time only special buy from Godbout on the nucleus of a Powerfull 16 Bit S-100 Computer. We have a limited number of these systems in stock, because of the special pricing we can't go back for more, so hurry! Orders will be filled on a first come basis. NO RAINCHECKS.

Here's what you get

1. 16 bit/8 bit Dual Processor (w/6 MHz 8088)
2. System Support 1 with Serial I/O. Real time clock, Interval Timers & More!
3. Disk 1 DMA Floppy Disk Controller (w/BIOS for CP/M *2.2)
4. 64K of fast static RAM (w/IEEE 24 bit extended addressing)
5. Sorcim's powerful PASCAL/M* - 8086 software on disk
6. Digital Research's CP/M* - 86 software on disk
7. I/O and Disk Controller cables, plus full documentation on all hardware and software

*PASCAL M is a trademark of Sorcim: CP/M is a registered trademark of Digital Research

It all adds up to $3430.00

A) TOTAL PACKAGE PRICE

$2495.00

SAVE $935.00

ORDER PART NO. GBT SPEC-A

SAVE EVEN MORE, when you add 2 Shugart 801R disk drives, and a dual Cabinet with Power Supply.

This package adds up to $4680.

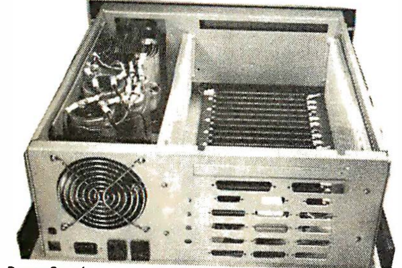
B) TOTAL PACKAGE PRICE

$3595.00

SAVE $1085.00

ORDER PART NO. GBT-SPEC-B

THE ULTIMATE SYSTEMS CALL FOR THE ULTIMATE SYSTEMS ENCLOSURE

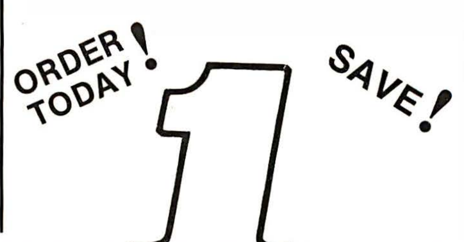


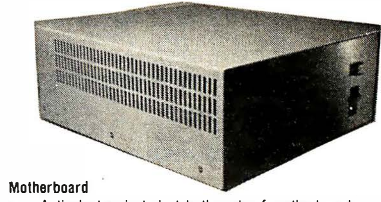
Power Supply
- Twenty-five Amps at 8.0 volts D.C.
- Three Amps each at + 16 and − 16 volts D.C.
- Outputs vary less than 5% over input range of 100 VAC to 130 VAC
- Constant voltage transformer
- All outputs fused

Enclosure
- Quiet fan provides for cool system operation
- Two switched convenience outlets on the rear
- Line filter for electrical noise suppression
- Circuit breaker for safe operation
- Lighted RESET BUTTON FOR "POWER ON" indication
- Punchouts on rear for 12 DB-25 connectors
- Punchouts on rear for 2 DD-50 connectors
- Positive pressurized for ease of filtration
- Provisions for mounting a front panel
- Physically 18.5" deep, 7" high, and 17" wide (rack front panel 19" wide)



Now ... a place to put all those CompuPro or other S100 boards. The enclosures are available in either desk top or rack mount (including slides) and both have the following features:





Motherboard
- Actively terminated at both ends of motherboard
- Ground shield between every signal trace
- Front panel provisions on the 20 slot version

	LIST PRICE	OUR PRICE
GBT ENC20RM 20 slot Rack Mount	895.00	825.00
GBT ENC20DK 20 slot Desk Top	825.00	760.00

Shipping Weight 55 lbs

When purchased with any of the above systems........

GBT ENC20RM	**$750.00**
GBT ENC20DK	**$685.00**

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KIM

$25 **$21**

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- ☐ 6502 ASSEMBLER (With Macros)
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Seattle, Wa. 98177

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Rational Fortran preprocessor allows structured programming using Fortran. An excellent, fast implementation with extensions and manual.
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PPRATFOR- Automatically pretty prints and indents Ratfor. Requires Ratfor.
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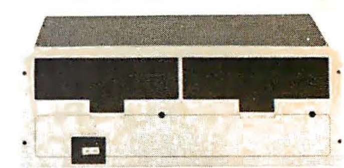
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Disk Drive Subsystem with Dual Double Side Drives, Power Supply and Cable. Total Capacity 2.4 M-Byte. Fully Assembled and Tested.

Only !!

1. Table Top Version $1,695.00
2. Rack Mount Version 1,695.00
3. Pair of Slides with Attachment for Rackmount 35.00
4. S100 Disk Controller (handles single & double density in 256, 512 & 1024 byte sectors, single & double side) 350.00
5. Double Side Disk Drives (1.2 mb) .... 535.00 (Qume DT/8)

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OSM Computer Corporation
2364 Walsh Avenue
Santa Clara, CA 95051

Circle 160 on inquiry card.

Hard Copy Printer For Your Computer

Completely Refurbished Teletype Model 33 RO

Friction Feed Table Model, 110 Baud, 8 Level ASCII, operated from 20MA or 60MA Loop specify.

$279.95

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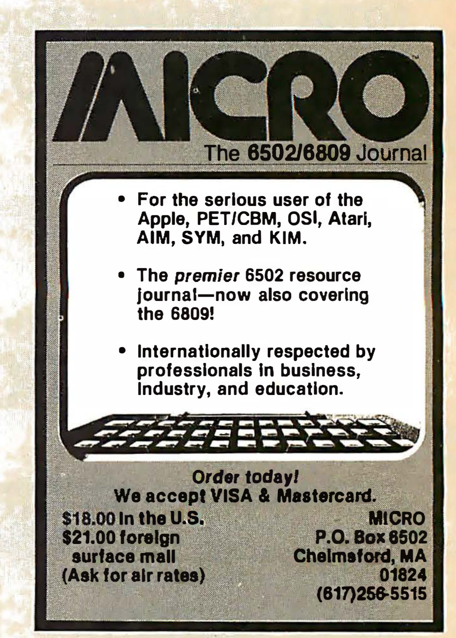
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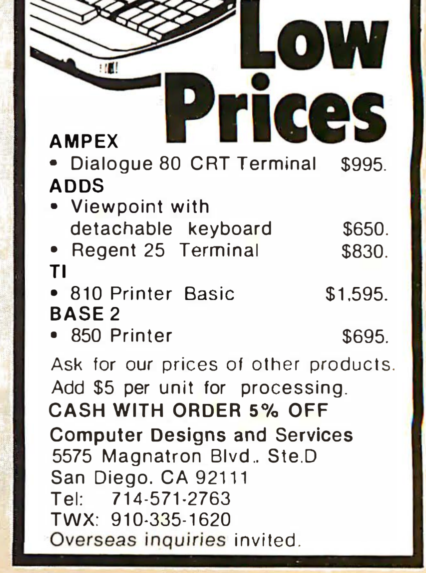
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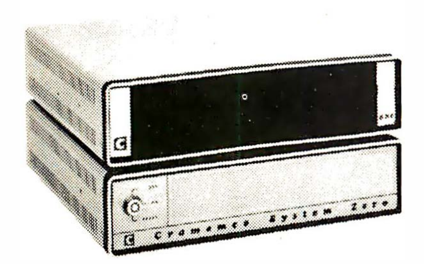
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64K Double or Quad Density units available. Uses two Z-80 CPU's. Commercial-type terminal with 12" monitor. Dual double density minifloppies. Over 350 kilobytes of storage (twice that with quad density drives). Two serial RS232 ports, I/O ports standard. Expandable with optional S-100 interface. Comes with CP/MTM 2.2 operating system. MiniMicroMart can supply a wide range of CP/M development and application software.

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26 megabytes of formatted storage
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1410 w/numeric keypad, List $900 . . . . . . $749
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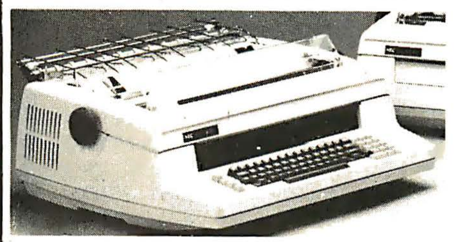
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NEW 730, parallel, friction, tractor $599
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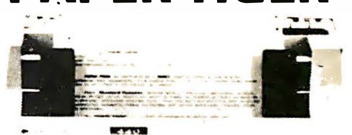
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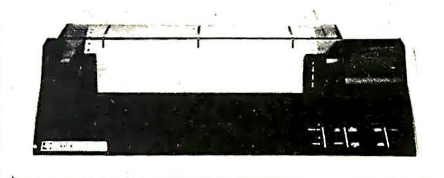


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QUALITY PRINTING AT MATRIX SPEED—LOGIC SEEKING PROPORTIONAL SPACING
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TI-810 Basic Unit, $1895 . **ONLY $1595**
TI-810 w/full ASCII (Lower case), vertical forms control, and compressed print . **$1795**
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ANADEX DP9500/DP9501 PRINTERS

DP-9500, List $1650 . . . . **$1349**
DP-9501, List $1650 . . . . **$1349**

ANADEX DP-8000 80-Col. Dot Matrix. **$849**

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Microline 80 List $599 **ONLY $499**
Tractor Feed Option **$109**
Serial interface . . . . **$ 99**
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Microline 83 List $1260 . . . . $1069

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Unclassified Ads

FOR SALE: Hazeltine 1500. Display terminal with typewriter-style keyboard and numeric pad. Unit was used only a few hours for display purposes. $650. John Joslyn, (213) 658-7190 days, (213) 763-0843 evenings.

FOR SALE: MITS Altair 88-DCDD floppy-disk drive and controller. Recently aligned and all ECOs installed. With all manuals and software including Altair Disk BASIC. $700. Diablo printer with stand, print wheels, ribbons, paper, and full documentation. $1250. Will deliver within 75 miles. Call to arrange demonstration. Alan Frisbie, 3786 E Mountain View, Pasadena CA 91107, (213) 351-2351 days, 796-7872 evenings.

FOR SALE: Two Burroughs 89352 video terminals—one complete, one without keyboard and video-driver boards. 960-character display screen. Flexible cursor controls. 5 by 7 dot matrix. Six baud rates. RS-232B. Manual and extra circuit boards included. $500 for the pair. Steve Olson, 6500 Halsey Dr, Woodridge IL 60517, (312) 852-0365.

WANTED: S-100 bus computer, must have video display, two 8-inch disk drives, and 48 K programmable memory. I have amateur radio equipment for trade. Dale Hutchinson, 10818 Brentway Dr, Houston TX 77070.

FOR SALE: Heathkit H-8 computer with 32 K bytes of memory. System includes serial I/O interface, cassette recorder/player, and H-9 video terminal. All manuals, documentation, and software included. Extras are dust covers and special program tapes. $1100 includes shipping. Keith Morlock, Rt #5 Box #263, Columbus MS 39701, (601) 328-8880.

WANTED: Information where I can find the King James Version of the Bible in computer-readable format on disk or cassette. I will accept collect calls if you have this information. Steven Tilden, 4771 S Warren Ave, Tucson AZ 85714, (602) 746-0569.

FOR SALE: TI Programmable 58. In excellent condition; almost brand new. Master Library Module and manuals included. Will sell for $75 or best offer. Eddie Stein, 7 Cumbernauld Ct, Rockville MD 20850, (301) 279-9533.

FOR SALE: Floating-point math board for RCA VIP with driver software, uses MM57109 uP; $35 US. HP-55 programmable calculator with timer, includes statistics and math manuals. Best offer or will consider trade for R/S Quick Printer II. Frank Shinyei, 10545 129 St, Edmonton Alberta, T5N 1W9 Canada.

FOR SALE OR TRADE: 64 K dynamic programmable-memory board for H-8 bus. Works through address selectable/set-able I/O port. Brand new, never really used, only tested. (Mom bought me this, but she doesn't know a byte from a carburetor.) I will give a 90-day warranty and documentation to first $500 check or money order, or will swap for two working WH8-16s. Kurt Schultz, 115-1 Roxanne Ct, Walnut Creek CA 94596.

FOR SALE: Barely used Apple communication card and Novation CAT modem. With cables and software. $275. Chris Pino, 125 Mansfield, New Haven CT 06511, (203) 562-0773.

FOR SALE: Centronics 101 printer, uppercase and lowercase. Cost over $5000, sell for $2500 or best offer. Machine is too large for my Commodore. Jerry Gaines, 4104 Fountain Green, Lafayette Hill PA 19444, (215) 828-4800.

WANTED: Old mechanical calculators. Please describe what you have in detail, and include a picture if possible. SASE please. Dick Rubinstein, 15 Maugus Ave, Wellesley Hills MA 02181.

FOR SALE: Apple graphics tablet in excellent condition; $450. Hitachi high-resolution 9-inch black-and-white monitor; $125. SwTPC PR-40 printer with parallel card for Apple slot two; $175. Comprint 912s, a fast 80-column printer with full uppercase and lowercase for RS-232 input; $250. Apple serial interface card, bidirectional RS-232 with DB-25 connector; $100. Frank Jaubert, 823 Euclid St, Houston TX 77009, (713) 868-0034.

WANTED: I have a National Semiconductor IMP-16C 16-bit microprogrammable microcomputer, CUTIL monitor, PACE instruction set, figFORTH for PACE, 6-slot card cage, wire-wrap board, power supply, and documentation, all new. I need a front panel or serial interface, or schematics for same. If not, I'll sell all for $2150. Lee A Hart, 366 Cloverdale, Ann Arbor MI 48105, (313) 994-0784.

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These notices are free of charge and will be printed one time only on a space available basis. Notices can be accepted from individuals or bona fide computer users clubs only. We can engage in no correspondence on these and your confirmation of placement is appearance in an issue of BYTE.

Please note that it may take three or four months for an ad to appear in the magazine.

ADVENTURE ENTHUSIASTS: I am trying to form a noncommercial original adventure software exchange. I need people who are interested in writing and exchanging adventure software. I am proposing a national mail-correspondence club dedicated to this purpose. I have written a BASIC adventure to start things off with. If you have an interest in this idea, please write me. Paul Callahan, 632 Deaver Dr, Blue Bell PA 19422.

FOR SALE: Heath H-9 modified for a 24 by 80 display. All manuals included. $200. Michael L Couch, 1218 18th St, West Des Moines IA 50265, (515) 223-0549.

WANTED: Good clean copy of BYTE magazine for December 1975 (#4). Please give price including packaging and transportation. George Frater, 1730 Mariposa Dr, Las Cruces NM 88001.

FOR SALE: HP-67 calculator with standard pack, cards, manuals, and all original accessories, including case, charger, and program pad. Brand new in original box. Perfect condition. $300 or best offer. Robert Peraino, 470 Claremont Rd, Springfield PA 19064, (215) 544-0947 after 9 PM.

FOR SALE: SwTPC 4 K memory; $50. 8 K memory; $100. JPC CK-7 real-time clock with auxiliary power supply; $50. MicroWare RT/68 monitor read-only memory; $50. All in excellent working condition with full documentation. C R Silvia, POB 234, Hines IL 60141.

FOR SALE: Three Forms Feed Option Kits (LAXX-LV) for DECwriter LA35 or LA36. Adjustable for many different form lengths. Regular price is $175 per kit. These are new, in original cartons, for $100. Also, BYTE issues 1 thru 16. No splits, please. Marshall MacFarlane, 13506 Lakebrook, Fenton MI 48430, (313) 629-0961 after 7 PM ET.

WANTED: Contact with owners of Disk Jockey 2D 8-inch disk system and switchboard I/O. Would like to interface Centronics 779 to system. Also, Wameco QM812 for sale. $75 or best offer. Daniel Snyder, 561 5th St, Butler PA 16001, (412) 287-1625.

WANTED: Manuals for Altair 8800 computer system. Will purchase. Don Averill, Eastern New Mexico University Sta #33, Portales NM 88130.

WANTED: Still photographs of pre-1960 computers, computer facilities, and computer scientists and engineers; also, cine footage, sound or silent, in any size, of same. Would also like to hear from other computer archivists/historians to form possible association or similar special-interest group. H Kent Craig, POB 975, Cary NC 27511, (919) 851-5017 evenings.

FOR SALE: Dot-matrix printer, Emako 20 (manufactured by C Itoh). 60 lpm, pin feed, 96 ASCII characters, 80-column, with cable for TRS-80, plugs into expansion interface. Original $770, asking $400. Also, twelve 5-inch diskettes; $2.50 each. Philip Crawford, 1720 E 1st St #10, Long Beach CA 90802, (213) 591-2484.

FOR SALE: Okidata Microline 80 printer with forms tractor, pin and friction feeds. State of the Arts 80 cps dot matrix. Includes parallel interface cable. 80- or 132-column. Excellent condition, complete with manual. $500. Clay Roberts, POB 129, Comptche CA 95427, (707) 937-4753.

FOR SALE: Twenty-three years of computing history. 276 issues of DATAMATION magazine. November 1957 thru December 1980. (Only two issues missing.) $500 plus shipping. R L LaFara, 10632 E 79th, Indianapolis IN 46236, (317) 823-6366 evenings.

WANTED: I am interested in exchanging ideas about possible ways computers can be used as an aid for guitar playing, in particular the application of computers for arranging and composing music on the guitar. I am currently writing a program that will find an optimum tuning for a given piece of music from the thousands that are possible. Bruce Johnston, 655 Sharp Ln 130, Baton Rouge LA 70815.

GIFT: HP-9100-A computing calculator. Sixteen registers store 197 steps. All math and trig functions, conditional jumps. In operating condition, but erratic. Will donate for cost of shipping. Winslow Palmer, 114 Montrose Dr, Fort Myers FL 33907, (813) 481-0027.

FOR SALE: APF Imagination Machine microcomputer. Power supply, RF modulator, cassette recorder, joysticks, and much software included—ready for hookup to television (it has color graphics and sound). Like new condition, over twenty programs, including Space Destroyers, Boxing, Baseball, and Hangman. The value of this system with software is over $800, willing to sacrifice for $600 or best offer. Bruce Chapman, 316 Newtown Rd, Richboro PA 18954.

FOR SALE: Pascal Microengine. Western Digital desk-top computer with 16-bit processor, 32 K words (64 K bytes) of programmable memory, floppy-disk controller, two RS-232C asynchronous/synchronous parts, and software (UCSD Pascal). $3400. G Mann, 9 Aberdeen, Irvine CA 92714, (714) 731-6145.

FOR SALE: Z80 Starter Kit from S D Systems, assembled and tested. Will sell for $325. Lee Rathbun, POB 1268, Minden NV 89423, (702) 782-4455.

FOR SALE: Altair 8800B with processor, front panel, and motherboard; $400. 3P + S; $100. 8 K static 300 ns; $100. Two Z16 16 K static memory boards; $200 each. North Star single-density disk controller board; $50. 4 K MITS static memory; $75. Will sell as package for $900. Bob Fiorella, 27 Kirkwood Dr, Glen Cove NY 11542, (516) 676-1480 after 6 PM ET.

FOR SALE: Hewlett-Packard (Mosely) 8.5-by 11-inch flatbed plotter, good condition; $150. Digital Group PT-96 complete printer, like new; $300. Complete DISKMON for 5-inch floppies (original, including ROM, etc); $30. Digital Group 5-slot memory-extension motherboard with all connectors installed; $20. 10-day return privilege guarantee on all above. Jerry E Flanders, 1767 Gregory Lake Rd, N Augusta SC 29841, (803) 278-0984 after 6 ET.

FOR SALE: 16 K Atari 800 personal computer. Brand new and unused. Unopened in original carton, with manual. Cost $1080, for $810 plus shipping. Atari disk drive, brand new. Cost $700, for $520 plus shipping. HP-97 desk-top programmable printing calculator, one month old. Cost $750, for $650 plus shipping. Extensive software library for Atari, TRS-80; write for details. Doug Solomon, 208 Overbrook, Freehold NJ 07728.

FOR SALE: SwTPC 6800 computer, 16 K programmable memory, teletypewriter interface, parallel interface, cassette recorder, cables, dual cassette recorder, 16 by 32 terminal, 64-character set, 9-inch black-and-white monitor. Complete with $100 worth of software and 4 K and 8 K BASIC, Editor/Assembler tapes. Asking $550 or best offer. John Antypas, 49 DeLaurenti Ct, Walnut Creek CA 94598, (415) 943-7409.

WANTED: Bally computer users. Would like to exchange information on the Bally home computer. Want old newsletters, system information, and read-only memory listings. If you know of a group (or person) using the Bally, I would like to have their mailing address. Also, give them my address so we can exchange information. Interested in additional unit at a good price, also other hardware. BALLYuserexch, POB 28355, Columbus OH 43228.

BOMB

BYTE's Ongoing Monitor Box

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March BOMB Results

Gregg Williams and Franklin C Crow tied for first place for their articles, "Structured Programming and Structured Flowcharts" and "Three-Dimensional Computer Graphics, Part I." A check for $100 will be sent to Mr Crow. (Being a BYTE employee, Gregg is not eligible for the prize money.) The second-place prize of $50 goes to Tim Ahrens, Jack Browne, and Hunter Scales for their article, "What's Inside Radio Shack's Color Computer?" The next two places went to Steve Ciarcia's "Build the Disk-80" and Jim Howard's "What Is Good Documentation?"

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June 1981
4161

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